DEER NUTRITION IN ARIZONA CHAPARRAL AND DESERT HABITATS

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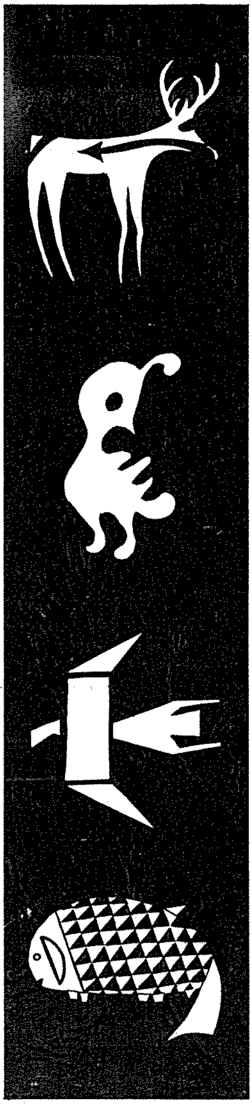

Special Report No. 3
September 1973

Arizona Game and Fish Department

U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station

DEER NUTRITION IN ARIZONA CHAPARRAL AND DESERT HABITATS

Part I: Seasonal Diets of Mule and White-tailed Deer

by Clay Y. McCulloch[1]

Part II: Chemical Analyses and In Vitro Digestibility of Seasonal Deer Forages

by Philip J. Urness[2]

Part III: Nutritional Value of Seasonal Deer Diets

by P.J. Urness and C.Y. McCulloch

RESEARCH DIVISION
ARIZONA GAME AND FISH DEPARTMENT

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
U.S. FOREST SERVICE

Special Report No. 3

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FOREWORD

The deer populations of the Three Bar Wildlife Area declined dramatically during the early 1960's and have since failed to recover in any significant way. This local decline was a reflection of what happened over most of Arizona's deer range. The reduced deer populations prompted the start of several investigations of deer population dynamics, production rates, and nutrition. This bulletin now brings to a close an important phase of this research effort. In it Drs. McCulloch and Urness answer the question, "Is nutrition an important regulating factor of chaparral and desert scrub deer herds." The bulletin also provides a basis for prescribing chaparral treatments that will protect or enhance the nutritional value of this habitat type.

Part I is the result of research begun in 1960 by Dr. McCulloch to determine what effect converting small chaparral watersheds to grass had on preferred deer foods. Until this work began most of our knowledge of deer food preferences was limited to the fall season. To fill in the gaps in our knowledge deer rumens were collected in all seasons of the year over the next 10 years in chaparral and adjacent desert scrub habitats. The data obtained is presented in Part I of this bulletin. Some of this information was summarized briefly in an earlier paper (McCulloch, 1972).

The nutritional analysis of seasonal deer foods by Dr. Urness comprises Part II of this bulletin. This work was conducted independently of McCulloch's studies but his data on diet composition and seasonal feeding periods served as the basis for evaluating the nutritional adequacy of deer diets in these habitats.

The objective of Urness' work was to determine if nutritional deficiences were a factor in the poor recruitment rates experienced by the Three Bar deer herd. The results of his studies have contributed greatly to our knowledge of one important factor affecting deer survival and mortality.

Part III of this bulletin dovetails these two independent research efforts in a unique way. Seasonal diets and their nutritional values were used to derive some actual seasonal nutrient intake estimates. These values can serve as criteria for judging the nutritional adequacy of deer habitat so far as general nutritional standards are available for comparison.

This publication should serve as a valuable reference for wildlife and range managers on important white-tailed deer and mule deer food plants in typical chaparral and desert scrub areas. It will be an important aid in designing prescriptions for habitat manipulation which will benefit deer populations.

Robert A. Jantzen, Director
Arizona Game & Fish Department
August 1973

ACKNOWLEDGEMENTS

The diet composition studies were done under Federal Aid Projects W71R and W78R, Arizona Game and Fish Department. Cooperating were the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station at Tempe, and the Zoology Department, Arizona State University. A.C. Crilley, G. Massaro, and N.G. Woolsey analyzed the stomach samples and helped or advised in other phases of the work. Other contributors in field, lab, or office were E.L. Fitzhugh, S. Gallizioli, R. Garcia, D.J. Illige, T.J. McMichael, R. Parent, J. Reed, H. Shaw, R.H. Smith, W.G. Swank, A. Thomas, and R.K. Watkins.

Nutritional studies were conducted by the U.S. Forest Service. Rocky Mountain Forest and Range Experiment Station with Arizona Game and Fish Department cooperating. W. Green and R.K. Watkins collected forage samples and aided in deer collections to obtain rumen inocula for *in vitro* digestibility trials. Others involved in deer collections were A.C. Crilley, T.J. McMichael, and N.G. Woolsey. Chemical analyses were made by the Rocky Mountain Station's Rapid City Laboratory under the direction of D.R. Dietz. J. Ruiz and A. Turbin typed the many revisions of the manuscript and aided the study in many other ways. The authors also acknowledge the advice and help of H.A. Pearson and H.G. Reynolds, whose interest made the nutritional study possible.

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Part I: Seasonal Diets of Mule and White-tailed Deer

by Clay Y. McCulloch

INTRODUCTION

Part I of this Bulletin describes seasonal composition of stomach contents of two deer species of central Arizona, the Coues white-tailed deer *(Odocoileus virginianus couesi)* and mule deer *(O. hemionus)*. The purpose of Part I is to provide bases for evaluating seasonal qualities of the diets and planes of nutrition in relation to herd productivity, discussed in Parts II and III. Part I is one aspect of a study to evaluate effects of brush conversion projects on deer. Those projects tend to be directed at life forms rather than species of plants. The graphs and tabulations which follow therefore emphasize life forms.

There is a dearth of information on local food habits of deer in Arizona. Generalized, regional descriptions of deer food habits tend to have limited usefulness for local wildlife management and land use planning (Martin et al. 1951). Deer adapt to a great variety of foods and their diets differ from one range to another and from season to season. This variability leads to misconceptions about the apparent importance of food plants. In one case, turbinella oak *(Quercus turbinella)* was thought to be of little value as deer food (Swank 1958:44). In another, it was reported that winter-spring moisture more commonly produced "worthless" plants, such as burroweed *(Aplopappus spp.)*, instead of "worthwhile" forage (Ariz. Sec. Newsletter, Amer. Soc. Range Mange., May 1969). Such impressions are subject to change as knowledge of deer food habits expands. The present Bulletin shows that turbinella oak acorns were locally important in deer diets, as were many herbaceous species which grew among the burroweed during and after the winter rainy season.

STUDY AREA

This study was done on the Three Bar Wildlife Area (64 $miles^2$) of the Tonto National Forest at the southern end of the Mazatzal Mountains, in Gila and Maricopa counties of south-central Arizona. Forage available for large herbivores on this range was lightly used as compared with other ranges nearby. The Three Bar area has been closed to livestock grazing since 1947, and deer herds were subject to some degree of control by either sex hunts, 1961-1968 (Smith, McMichael and Shaw 1969).

Topography of the Three Bar area is rough with steep ridges separating deep ravines which drain east and south. Elevations above sea level range from 2000-7000 feet in an airline distance of 6 miles. The area is geologically complex, containing granitic, sedimentary, metamorphic, and volcanic rocks and perched beds of unconsolidated sands, silts, and gravels (Wilson et al. 1957, 1959). Species composition, form, and phenological state of the vegetation vary with these sharp differences among sites in slope aspect, elevation, and geologic strata. Most of these site conditions occur within home ranges of individual deer. For example, continuously observed mule deer moved as far as 2 miles/day airline, and white-tailed deer, 0.7 mile/day. One mule deer buck was seen 4.5 miles from the marking site within 3 weeks after the animal was branded with paint from a set gun.

Chaparral consisting of 20-30 shrub species, occupies 1/3 of the Three Bar area. Most are broad-leaved evergreen forms which reproduce vigorously by root sprouting after wildfire. Shrub crown coverage estimates were as high as 80 percent on some sites in mature chaparral. Species composition of shrub stands is quite variable among sites within the chaparral (Table 1).

Mixed desert vegetation occupies 60 percent of the Three Bar area and is characterized by jojoba *(Simmondsia chinensis)*, deciduous thorn-shrubs, and grassland (Table 2). Although jojoba is also a broad-leaved evergreen shrub, it is typically not of chaparral associations despite much interfingering of desert and chaparral stands on opposing slopes at 3000-4000 feet elevation. Riparian communities, mountain-top woodland and coniferous forest comprise the remainder of the Three Bar area.

Mule deer are more abundant at the lower elevations and white-tailed deer at the higher, although both species occur at all elevation zones (Table 3). They were occasionally seen together on south-facing slopes of desert grassland at elevations between 3500-4000 feet.

Wildfire in 1959 burned 5000 acres of chaparral within the Three Bar area, and much larger acreage adjacent but outside of the Three Bar boundary. Regrowth was rapid and shrub cover at the end of the 1960-1970 study period much resembled pre-fire conditions. In 1966, another wildfire burned 6000 acres in the desert zone of the Three Bar area.

The seasonal pattern of precipitation greatly affects deer forage supplies. Typical winters of the Three Bar area are cool and wet as compared with other seasons (Fig. 1). Low intensity, general storms occur from November through March. A warm, dry season extends through May and June. Thunder storms with localized but high intensity rainfall are common during the hot, wet season of July-September. October is the fall dry season.

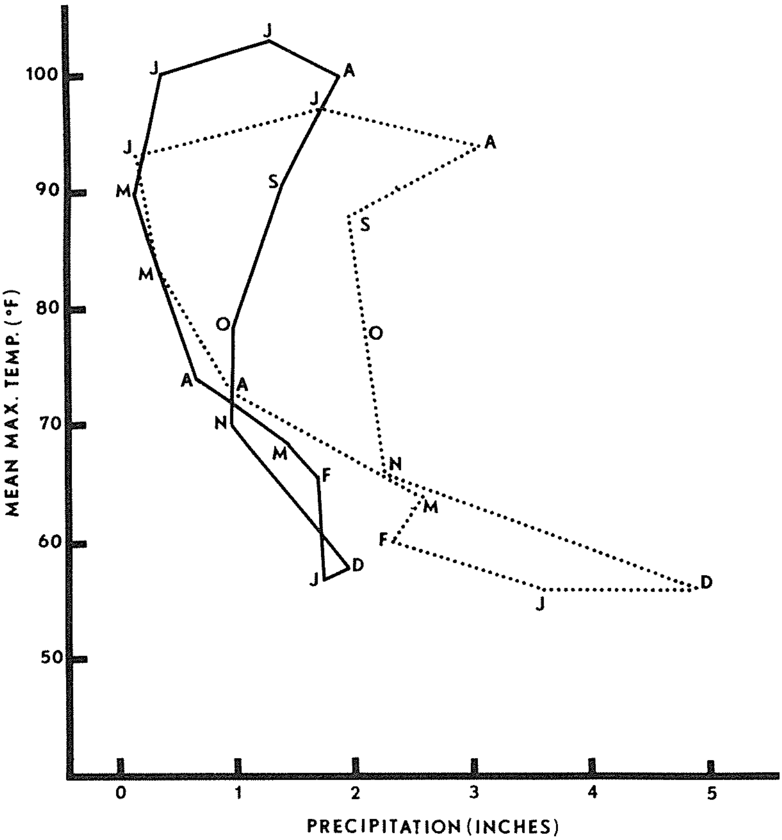

Figure 1. Climatographs, Three Bar and vicinity. Solid line represents mule deer zone (station at Roosevelt, elevation 2200 ft.). Dotted line represents white-tailed deer zone (station at Watershed C, elevation 3500 ft.).

Table 1. Occurrence (%) of woody plants in chaparral, Three Bar area[1].

Species	Range among 3 watersheds elevation 3500-4000 ft	Range among 3 watersheds elevation 4000-5000 ft
Quercus turbinella	87-94	60-91
Cercocarpus betuloides	45-84	14-84
Garrya flavescens	15-64	42-73
Ceanothus greggii[2]	3-13	0-61
Rhus ovata	23-31	2-59
Rhamnus crocea	26-34	26-52
Quercus emoryi	3-55	2-51
Ceanothus integerrimus	0-18	18-52
Quercus dunnii	23-47	8-39
Rhus trilobata	15-36	0-21
Yucca baccata	1-19	11-34
Fraxinus anomala	1-28	1-30
Lonicera interrupta	5-24	0-14
Quercus arizonica	0-4	0-48
Amelanchier bakeri	0-3	0-19
Rhamnus californica	0-6	0-17
Acacia greggii	0-14	0-6
Nolina microcarpa	0-8	0-7
Arctostaphylos pungens[2]	0-1	0-13
Eriodictyon angustifolium	1-5	0-9
Calliandra eriophylla	2-8	0-1
Prunus serotina	0-2	0-10
Mimosa biuncifera	1-6	0-2
Krameria parvifolia	0-7	0-2
Arctostaphylos pringlei[2]	0-1	0-6
Dasylirion wheeleri	0-1	0-2
Morus microphylla	0-2	0-1
Berberis haematocarpa	0-2	0-0
Ptelea angustifolia	0-0	0-1
Garrya wrightii	0-0	0-1
Platanus wrightii	0-1	0-0
Quercus gambelii	0-0	0-1

1/ 1021 sample plots diameter 23.6 ft each.

2/ Low occurrences were on areas sampled 2 years after wildfire; high, at 14 years post-fire. These 3 species reproduce by seed and restore their stands less rapidly than root sprouting forms.

Table 2. Occurrence (%) of shrubs, half-shrubs, and cactus in desert zone, elevation 2000-3500 ft, Three Bar area[1/].

Species	Slope aspect SE-SW	Slope aspect NW-NE
Predominant on warm slopes		
Simmondsia chinensis	80	41
Calliandra eriophylla	54	30
Cercidium spp.	43	9
Encelia farinosa	38	13
Eriogonum fasciculatum	26	17
Opuntia engelmannii	26	18
Opuntia acanthocarpa	26	14
Acacia greggii	24	16
Opuntia bigelovii	16	6
Echinocereus triglochidiatus	15	4
Ephedra viridis	14	13
Janusia gracilis	12	6
Lycium exsertum	12	6
Encelia frutescens	12	6
Porophyllum gracile	11	6
Carnegiea gigantea	11	2
Opuntia fulgida	10	7
Fouquieria splendens	10	6
Ferocactus wizlizeni	2	2
Mammillaria spp.	2	trace
Celtis pallida	1	1
Dyssodia porophylloides	1	1
Condalia lycioides	trace	0
Predominant on cool slopes		
Quercus turbinella	3	39
Eriogonum wrightii	11	34
Aplopappus laricifolius	23	26
Lotus rigidus	8	17
Cercocarpus betuloides	4	17
Sphaeralcea spp.	8	13
Krameria parvifolia	6	13
Nolina microcarpa	0	13
Yucca baccata	12	12
Galium stellatum	7	9
Prosopis juliflora	4	8
Penstemon microphyllum	3	8
Ceanothus greggii	1	8
Canotia holacantha	1	7
Rhus ovata	trace	7
Dasylirion wheeleri	1	6
Rhamnus crocea	2	3
Dodonea viscosa	2	3
Eriodictyon angustifolium	1	3
Rhus trilobata	0	3

1/ 515 sample plots diameter 23.6 ft each.

Table 3. Distribution of deer species by elevation zones, Three Bar area.

Elevation above sea level (ft)	Sightings (%) by zones[1/] White-tailed deer	Sightings (%) by zones[1/] Mule deer	Observer effort (%)	Vegetation South slopes	Vegetation North slopes
2000-3000	1	62	58	Desert shrub & cactus	Desert grassland
3000-4000	86	37	33	Desert grassland	Chaparral
4000-7000	13	1	9	Chaparral to live oak woodland	Chaparral to live oak woodland to pine
Total	100	100	100		

1/ 1415 deer observations, 1952-1955.

METHODS

Samples of stomach contents were taken from deer killed on the Three Bar area. Most were from animals shot by licensed hunters during special controlled hunts. The remainder of the samples represented deer collected by Department personnel. The latter collections were spaced over a period of nearly 10 years, so that kills for study purposes would not be excessive in any one year. Each rumen sample, consisting of ½ pint to 2 quarts of material, was washed in a sieve of 1/12-inch mesh. Volume composition of each sample retained on the screen was estimated either by ocular estimate or by the point frame method (Chamrad and Box 1964).

The white-tailed deer samples were taken from animals within the elevation zone 3000-5000 feet and those from mule deer, 2000-4000 feet. The compilations are for stomachs only from areas of native vegetation not recently disturbed, except for the 1959 wildfire on part of the chaparral zone.

Three characteristics of the stomach contents were tabulated. One describes average volume of each food in stomachs of the sample group of deer. The second characteristic, occurrence, tells what percentage of the deer ate at least a trace of each food. The third, greatest volume per sample, shows how much some individual sample differed from the average volume for each food. Thus, a table may indicate that a certain food was commonly eaten in appreciable amounts by a group of deer; that another was eaten by the group but generally in small amounts; and that another food was eaten infrequently by the group but in large amounts by one or a few individuals.

Presumably, the preference of deer for a food was reflected by amount of a given food consumed in relation to its availability in the deer habitat. Judgments of deer preferences were made only for foods of conspicuously different abundance on the study area and in the stomachs.

Composition of shrub stands was determined by species occurrence on systematically spaced plots on 3 arbitrarily selected watershed basins in each of 2 elevation zones within the chaparral. They were small watersheds of 40 to 250 acres each. The desert shrub stand below the chaparral zone was sampled for species occurrence as a much larger single unit of 39 square miles also by systematically spaced plots (Shaw 1965).

Summers of certain years were classed as "wet" or "dry" on the bases of precipitation records at Reno Ranger Station and Roosevelt (U.S. Dept. Commerce). The weather stations are respectively 10 miles north and 2 miles east of the Three Bar area, at 2350 and 2200 feet elevation. Data from the United States Forest Service, Rocky Mountain Forest and Range Experiment Station, represent precipitation at the 3500-foot elevation within the Three Bar area.

DISCUSSION

Midsummer Diet Composition

White-tailed deer stomachs in July and early August contained chiefly the green to ripe fruits from tall shurbs of desert grassland and chaparral sites (Fig. 2; Table 4). Nuts, beans and berries were abundantly available on the area from late June through August (Fig. 3). Forbs were of secondary abundance and importance in midsummer diets of white-tailed deer. Evergreen browse, always present in their habitat (Fig. 3), was mature, tough and appeared as a minor item in the diet.

Mule deer, like the white-tailed deer, fed heavily on the nuts and beans of tall shrubs in midsummer (Fig. 4; Table 5). Secondary diet items were foliage of the deciduous dwarf shrub, calliandra *(Calliandra eriophylla)* and browse from several evergreen shrubs. Palatable green forbs are generally not abundant at the lower elevations of the Three Bar area in summer. That scarcity was reflected in the small forb component of mule deer stomach contents in July and August.

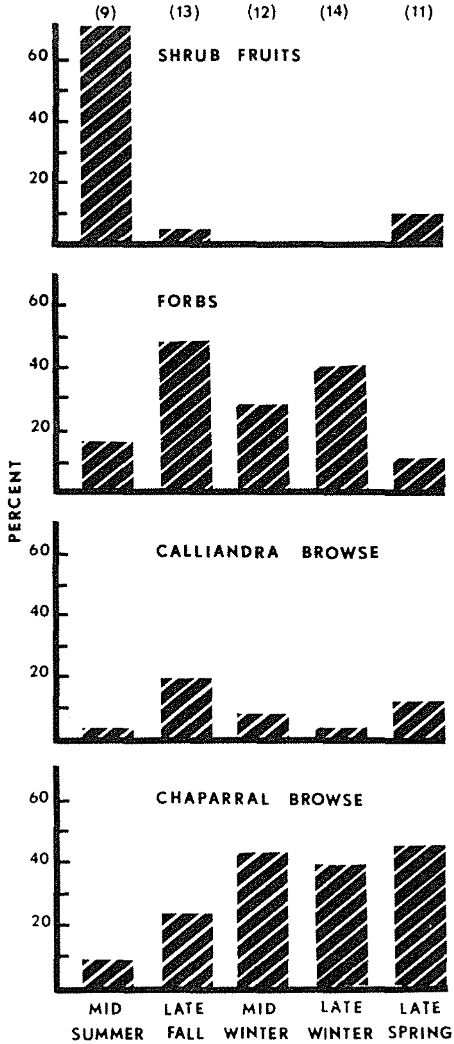

Figure 2. Seasonal differences in volume composition of white-tailed deer stomach contents. ( ) = No. stomachs.

Early Fall Diet Composition

During the normally dry early fall season of October., forbs and chaparral browse were the primary items in white-tailed deer stomachs. Shrub fruits were the secondary item. This generalization is based on only 3 stomach samples (Table 6), which were available from intact chaparral. Principal browse species eaten by these deer were bigleaf ceanothus *(Ceanothus integerrimus)* and holly-leaf buckthorn *(Rhamnus crocea)*. Berries of yellow-leaf silktassel *(Garrya flavescens)* were abundant in one of the stomachs. Browse of that shrub was scarce or absent in the several hundred deer stomachs examined during this study. Silktassel is common throughout chaparral stands (Table 1).

Calliandra leaves were the major food of mule deer in early fall (Fig. 4; Table 7). Despite the abundance of evergreen browse in the habitat only small amounts of this material appeared in mule deer stomachs during the October dry season.

Late Fall Diet Composition

Forbs and a mixture of browse from tall and dwarf shrubs were the main items in late fall (November-December) stomachs of white-tailed deer (Fig. 2; Table 8). This was a marked departure from the diet of the fawning season, and reflected the decreased availability of shrub fruits in the fall of the year (Fig. 3).

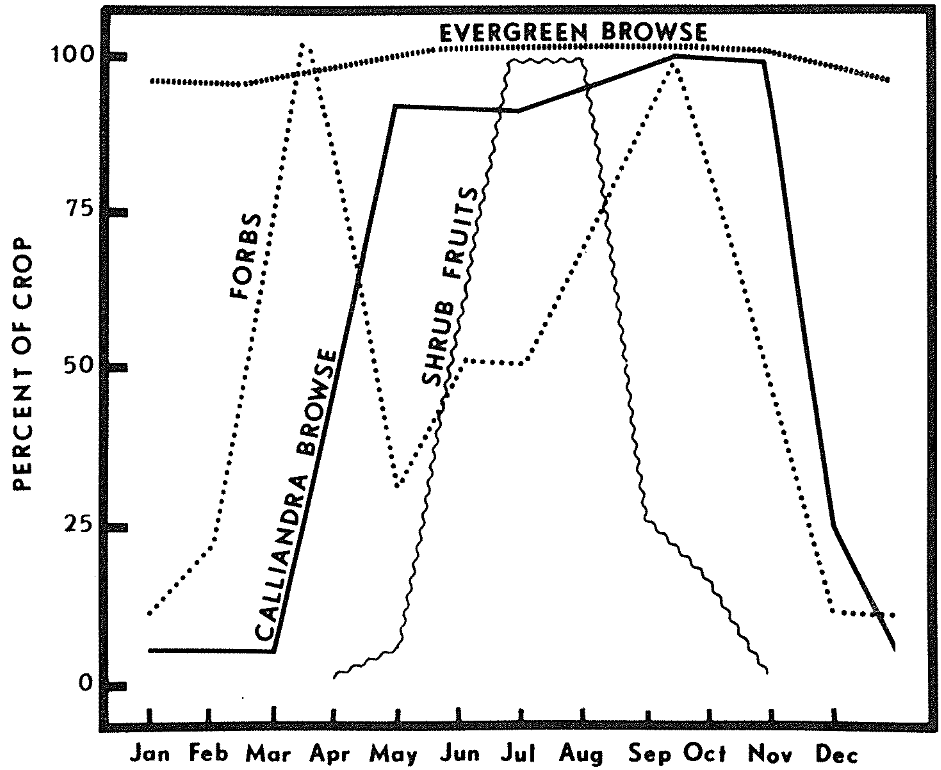

Figure 3. Seasonal availability of major deer foods, Three Bar area.

Staples for mule deer in late fall were the foliage of calliandra and of the desert evergreen shrub, jojoba *(Simmondsia chinensis)* (Fig. 4; Tables 9-11). Certain forbs and half-shrubs were also important in late fall mule deer diets in some years, e.g., artemisia *(Artemisia ludoviciana)*, spurges *(Euphorbia spp.)*, and the eriogonums, especially *Eriogonum wrightii* and *E. fasciculatum*. Palatable herbaceous forage in fall is generally more available in the higher elevations than in the zone of primary mule deer habitat. Effective precipitation for late summer plant growth is greater in the upper zone, and would explain why the white-tailed deer stomachs contained more forbs than those of mule deer at this season.

There were year-to-year differences in composition of stomach contents of mule deer in late fall (Fig. 5; Tables 9-11). Calliandra percentages were notably variable. The annual differences were associated with rainfall of the preceding summer, and with onset of frosts each fall. Dry summers, such as that of 1962, restrict late season growth of calliandra. Appreciable late summer growth of calliandra occurs in years of average or above-average summer rainfall, such as 1963 and 1964. The new growth is probably more palatable than the old foliage of the spring growing season.

Extensive leaf-fall from calliandra occurred after the first heavy frosts of fall or early winter, thus reducing availability of browse on that dwarf shrub. In some years, there were effective frosts in November but in other years, not until late December or early January. Dry summers also may have caused early partial defoliation and thereby decreased supplies of calliandra browse in some autumns.

Forb content of late fall mule deer stomachs also reflected moisture conditions of the preceding summer. Following the dry summer of 1962, forb percentage in the fall stomachs was low (Table 9). Wet summers of 1963 and 1964 preceded the greater consumption of forbs by mule

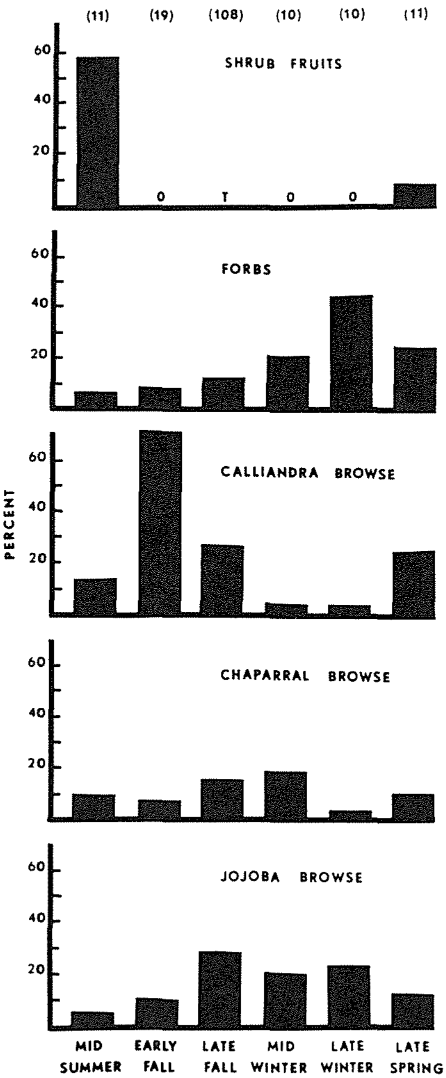

Figure 4. Seasonal differences in volume composition of mule deer stomach contents. ( ) = No. stomachs. Late fall is an average for 1962 and 1963 fall series only.

deer in the falls of those two years (Fig. 5; Tables 10, 11). There were not enough mule deer samples to permit year-to-year comparisons except for the late fall season. Nor were there enough white-tailed deer samples for this purpose for any season.

Midwinter Diet Composition

White-tailed deer ate more tough, old leaves of evergreen shrubs in January than during the fall (Fig. 2; Table 12). There was a marked decrease of calliandra in the samples. Only small amounts of foliage remained on the dwarf shrub in midwinter, mainly on warm slopes and at lower elevations. Forbs were still an important part of the white-tailed deer diet, although percentages had declined from late fall.

Mule deer also showed decreased consumption of calliandra in midwinter, with continued reliance on jojoba browse and increased use of chaparral browse species (Fig. 4; Table 13). The change from fall to winter diets was abrupt for both deer species as shown in the series of stomach samples collected within a 3-week period spanning onset of heavy frosts and leaf-drop of calliandra (Fig. 6, 7; Tables 13-15).

Late Winter Diet Composition

Evergreen browse content of white-tailed deer stomachs remained high through late winter (February-March), and forb content increased after January (Fig. 2; Table 16). Prominent late winter food items were perennial and annual herbaceous species which complete most of their growth during the cool season, after soil moisture recharge and the coldest midwinter period has passed. Grass-nuts *(Dichelostemma pulchellum)*, filaree *(Erodium cicutarium)*, and red brome *(Bromus rubens)* were examples.

Mule deer in late winter also fed heavily on the newly available herbaceous species. Evergreen browse became a secondary but still important portion of the mule deer diet (Fig. 4; Table 17).

Late Spring Diet Composition

Evergreen browse in late spring (May) was the most important food class for white-tailed deer (Fig. 2; Table 18). Chaparral shrub species in May were mostly in the active stages of annual growth and white-tailed deer then were eating largely the tender, new leaves.

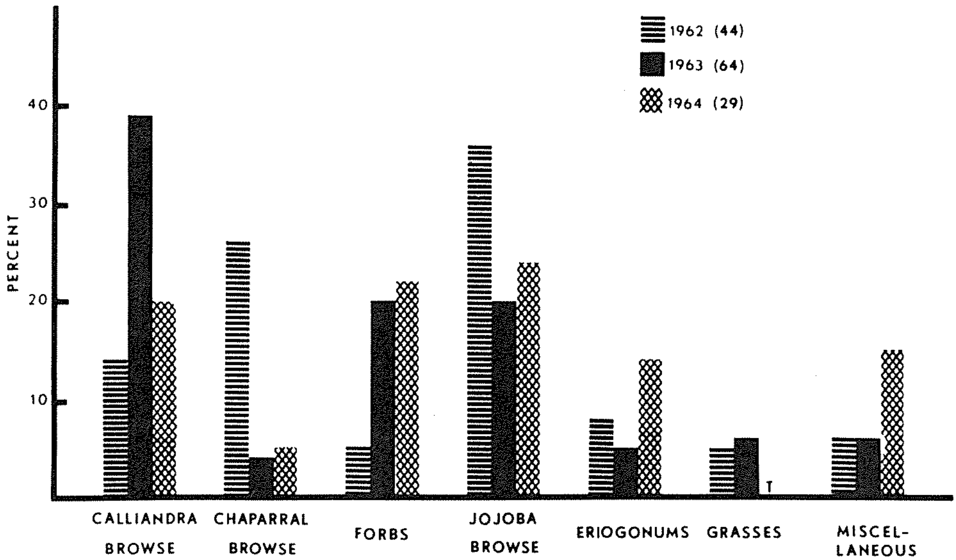

Figure 5. Yearly variations in late fall composition (volume) of mule deer stomach contents. ( ) = No. stomachs. 1962 summer was dry; stomachs were collected before frosts. 1963 summer was wet; stomachs were collected before frosts. 1964 summer was wet; stomachs were collected after frosts.

Dwarf shrub and half-shrub browse availability correspondingly increased from midwinter. Some cool-season herbaceous forages were beginning to wither, or had already done so, especially annuals. The reduced availability paralleled the decreased percentage of forbs in white-tailed deer stomachs.

Calliandra leaves were the main food item in mule deer stomachs during late spring; tender, new browse in general was the primary diet (Fig. 4; Table 19). Forbs declined to secondary rank as compared with amounts in late winter stomachs of mule deer.

General Forage Preference

There was a broad choice of forage available on the Three Bar area, and the deer did not select a pure diet of any one kind of food in any season (Fig. 2-9; Tables 1-20). Instead, both white-tailed and mule deer ate appreciable amounts of forbs, leaves of several deciduous dwarf shrubs and half-shrubs, leaves of evergreen shrubs from either desert or chaparral, the nuts, beans, and berries of shrubs, and small amounts of green grasses. More than 130 plant species occurred in the 368 deer stomachs examined (Table 20), although the average did not exceed 10 species per stomach in any seasonal series.

Refined judgments of deer preferences were difficult in this area of highly diversified vegetation because actual boundaries of habitats were undefinable for the animals which yielded the stomach samples. In general, deer of the Three Bar area preferred:

1. Herbaceous foods rather than mature evergreen browse.
2. Green rather than cured herbage.
3. New rather than mature foliage of evergreen shrubs.
4. Foliage rather than twigs of browse species.
5. Fruits rather than mature foliage of chaparral shrubs.
6. Forbs rather than grasses.

Although evergreen browse was not highly preferred, it was an important food as judged by amounts eaten and stability of supply. During late fall and winter, when other foods were least available (Fig. 3), the browse species most used by white-tailed deer were holly-leaf buckthorn, bigleaf ceanothus, desert ceanothus *(Ceanothus greggii)* and birchleaf

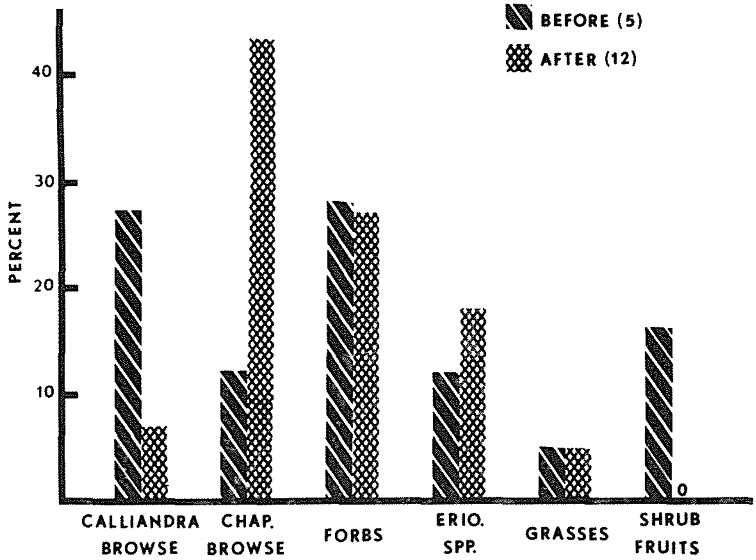

Figure 6. Composition (volume of white-tailed deer stomach contents vs. winter leaf-drop of calliandra. ( ) = No. stomachs.
Before — First fall temperature 28° or below occurred 12/24/66. Stomachs were collected 12/28-31/66.
After — Temperature 28° or below 12/24/66 and 12/21/67. Stomachs were collected 1/10-16/66 and 68.

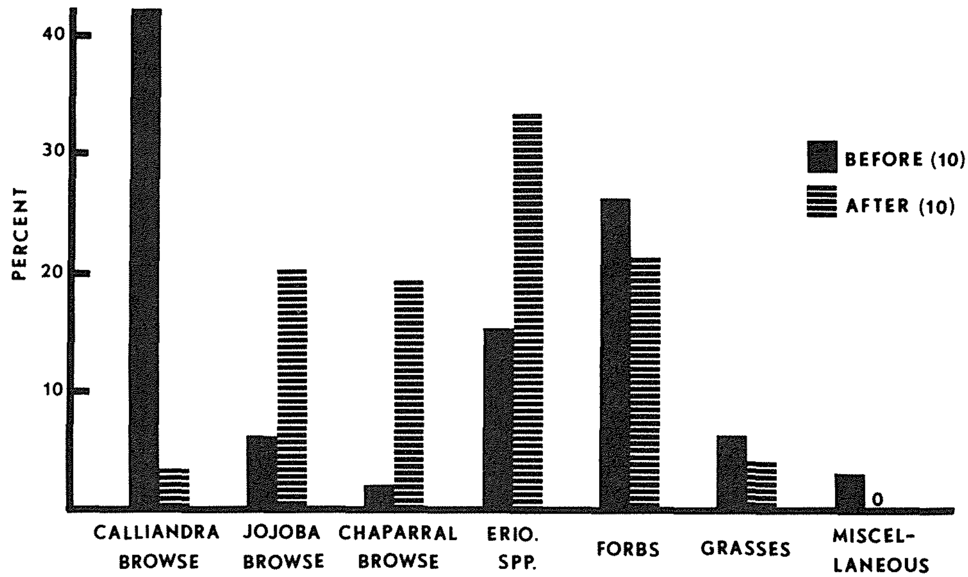

Figure 7. Composition of mule deer stomach contents vs. winter leaf-drop of calliandra. ( ) = No. stomachs.
Before – First fall temperature 28° or below 12/24/66. Stomachs were collected 12/28-31/66.
After – First fall temperature 28° or below, 12/24/66 and 12/21/67. Stomachs were collected 1/10-16/66 and 68.

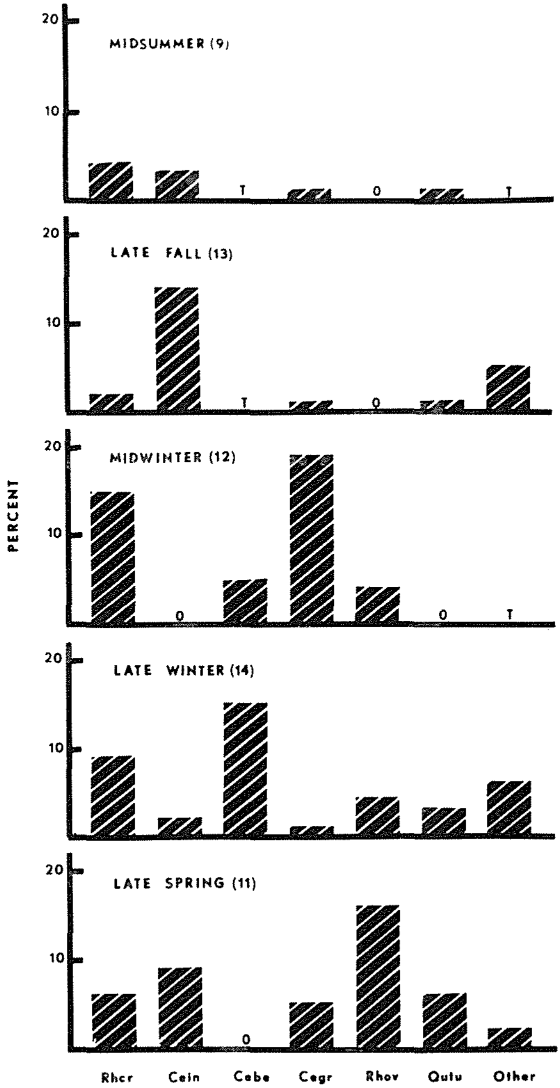

Figure 8. Composition (volume) of evergreen browse fraction in white-tailed deer stomachs. ( ) = No. stomachs.

mountain-mahogany *(Cercocarpus betuloides)* (Fig. 8). Of those four species, mountain-mahogany seemed the least preferred. It was conspicuously more abundant than the others of the Three Bar area generally, but not more prevalent in the deer stomachs. Deer use of mountain-mahogany increased in late winter, possibly because palatable new growth became available on selected plants on some of the warmer sites.

Jojoba was the only evergreen browse species abundant in mule deer stomachs (Fig. 9). Like white-tailed deer, the mule deer ate evergreen browse mostly in fall and winter when other foods were least available.

Some of the least preferred browse species were important food plants because of the palatable fruits which they produced for deer; e.g., turbinella oak (Tables 4, 5). Large-scale shrub control, for increased

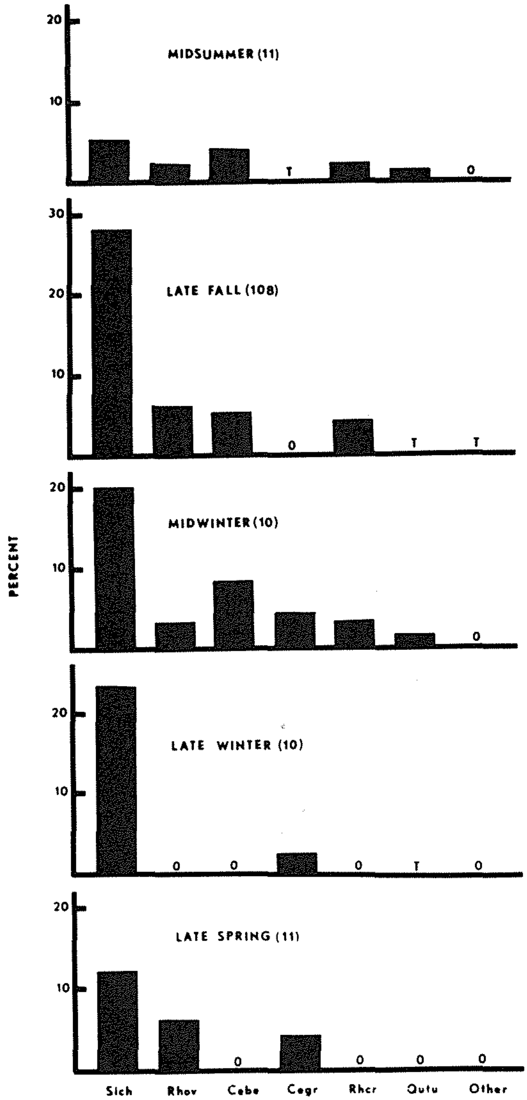

Figure 9. Composition (volume) of evergreen browse fraction in mule deer stomachs. ( ) = No. stomachs. Late fall is a weighted average of one dry and one wet year, 1962 and 1963 only.

water yields or livestock grazing capacity, could adversely affect fruit crops for deer and other wildlife. This factor should influence land manager's decisions relative to treatment size and intensity (Pase et al. 1967).

Preferences among forb species were especially difficult to judge. There were only small amounts of each forb species usually present in the stomachs, and relative abundance of forbs among stands on the range was not conspicuously different for many of the species. Two exceptions were snakeweed *(Gutierrezia sarothrae)* which was abundant in the deer habitat, but generally scarce in the stomachs and grass-nuts *(Dichelostemma pulchellum)* which was less abundant on the range but more prominent in stomach contents.

Table 4. Midsummer contents of 9 white-tailed deer stomachs (7 July - 2 Aug. 1962-1964, 1967).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Shrub Fruits	70	100	95
Quercus turbinella	33	89	77
Rhus trilobata	11	33	28
Prosopis juliflora	9	44	33
Quercus emoryi	9	11	82
Garrya flavescens	6	22	32
Acacia greggii	2	11	13
Forbs	16	100	82
Artemisia ludoviciana	13	44	82
Maurandya antirrhiniflora	2	11	16
Euphorbia spp.	1	78	2
Ayenia filiformis	t	44	4
Gnaphalium wrightii	t	22	5
Tall Shrubs, Browse Parts Only	9	100	43
Rhamnus crocea	4	56	17
Ceanothus integerrimus	3	22	23
Quercus turbinella	1	67	3
Ceanothus greggii	1	33	5
Phoradendron coryae	t	22	3
Rhus trilobata	t	22	3
Garrya flavescens	t	22	1
Cercocarpus betuloides	t	22	t
Dwarf Shrubs & Half-Shrubs	5	100	11
Calliandra eriophylla	3	78	11
Sphaeralcea spp.	1	11	11
Solanum xanti	1	11	7
Eriogonum spp.	t	33	4
Grasses spp.	t	44	2
Total	100	100	-

Table 5. Midsummer contents of 11 mule deer stomachs (5-31 July 1962-1964, 1967).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Shrub Fruits	58	100	93
Prosopis juliflora	29	73	93
Quercus turbinella	14	64	40
Acacia greggii	14	45	70
Simmondsia chinensis	1	36	5
Tall Shrubs, Browse Parts Only	16	100	59
Simmondsia chinensis	5	73	16
Cercocarpus betuloides	4	9	48
Acacia greggii	2	45	19
Rhamnus crocea	2	27	11
Rhus ovata	2	18	16
Quercus turbinella	1	36	3
Ceanothus greggii	t	36	2
Prosopis juliflora	t	36	1
Rhus trilobata	t	18	2
Celtis reticulata	t	9	5
Dwarf Shrubs & Half-Shrubs	16	100	33
Calliandra eriophylla	13	91	31
Eriogonum spp.	2	55	12
Sphaeralcea spp.	1	18	5
Krameria parvifolia	t	27	1
Forbs	6	82	16
Euphorbia spp.	2	64	8
Artemisia ludoviciana	2	45	16
Euphorbia incisa	2	18	8
Fern spp.	t	27	3
Mirabilis bigelovii	t	18	2
Cactus Fruits	4	36	23
Carnegiea gigantea	2	27	11
Opuntia engelmannii	2	9	23
Grasses spp.	t	45	1
Total	100	100	-

Table 6. Early fall contents of 3 white-tailed deer stomachs 10-28 October 1967-1968.

Food	Volume (%)			
	Average	10/10/67 #346	10/25/68 #370	10/28/68 #371
Forbs	35	57	46	1
Ipomoea coccinea	8	24	0	0
Ipomoea spp.	7	20	0	0
Euphorbia spp.	3	10	0	0
Artemisia ludoviciana	1	2	0	0
Margaranthus solanaceus	1	1	2	0
Artemisia spp.	2	0	6	0
Mentzelia pumila	2	0	5	0
Linum lewisii	8	0	26	0
Unidentified Forb spp.	2	0	4	1
Gutierrezia sarothrae	1	0	3	0
Tall Shrubs, Browse Only	37	25	44	43
Rhamnus crocea	15	16	16	13
Ceanothus integerrimus	12	9	12	15
Cercocarpus betuloides	2	t	3	3
Garrya flavescens	2	0	1	7
Ceanothus greggii	4	0	9	2
Rhus trilobata	1	0	3	0
Prunus virens	1	0	0	3
Shrub Fruits	17	0	4	47
Garrya flavescens	17	0	4	47
Dwarf Shrubs & Half-Shrubs	11	19	6	9
Calliandra eriophylla	6	17	0	0
Solanum xanti fruit	1	2	0	0
Eriogonum spp.	2	0	6	2
Sphaeralcea spp.	2	0	0	7
Total	100	100	100	100

Table 7. Early fall contents of 19 mule deer stomachs (20-25 Oct. 1961).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	75	100	100
Calliandra eriophylla	71	100	100
Porophyllum gracile	3	58	23
Eriogonum spp.	1	42	9
Janusia gracilis	t	32	6
Krameria parvifolia	t	21	1
Tall Shrubs, Browse Parts Only	17	100	72
Simmondsia chinensis	9	90	69
Rhamnus crocea	5	5	88
Cercocarpus betuloides	1	32	6
Phoradendron californicum	1	10	8
Rhus ovata	1	5	12
Acacia greggii	t	10	2
Ceanothus greggii	t	10	t
Mimosa biuncifera	t	10	t
Forbs	8	90	63
Artemisia ludoviciana	4	16	63
Euphorbia spp.	3	58	38
Compositae spp.	1	5	12
Franseria confertiflora	t	26	t
Menodora scoparia	t	10	9
Gutierrezia sarothrae	t	10	t
Grasses	t	58	1
Grass spp.	t	47	1
Bouteloua spp.	t	10	t
Hilaria belangeri	t	10	t
Total	100	100	-

Table 8. Late fall contents of 13 white-tailed deer stomachs (22 Nov. - 2 Dec. 1962-1964, 1967).

Food	Average volume	Occur-rence	Greatest volume per sample
	%	%	%
Forbs	48	100	87
Euphorbia spp.	15	92	42
Artemisia ludoviciana	15	69	41
Tradescantia occidentalis	7	15	53
Ipomoea coccinea	3	23	30
Erodium cicutarium	3	15	42
Margaranthus solanaceus	2	23	12
Cuscuta spp.	1	31	10
Dalea albiflora	1	8	14
Unidentified Forbs, 13 spp.	1	8	3
Convolvulus linearilobus	t	8	5
Penstemon spp.	t	8	5
Tall Shrubs, Browse Parts Only	24	100	79
Ceanothus integerrimus	14	31	79
Lonicera interrupta	3	15	25
Rhamnus crocea	2	46	6
Garrya flavescens	2	8	27
Ceanothus greggii	1	38	9
Acacia greggii	1	23	11
Quercus turbinella	1	15	5
Cercocarpus betuloides	t	23	1
Phoradendron californicum	t	8	5
Dwarf Shrubs & Half-Shrubs	21	69	78
Calliandra eriophylla	19	69	78
Eriogonum spp.	2	46	19
Solanum xanti fruit	t	23	3
Shrub Fruits	4	15	27
Quercus arizonica	2	15	21
Garrya flavescens	2	8	27
Grasses, spp.	3	23	36
Total	100	100	-

Table 9. Late fall contents of 44 mule deer stomachs (24 Nov. - 2 Dec. 1962), following a dry summer.

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Tall Shrubs, Browse Parts Only	63	100	100
Simmondsia chinensis	36	87	82
Rhus ovata	10	36	60
Cercocarpus betuloides	8	48	60
Rhamnus crocea	7	27	58
Prosopis juliflora	1	14	17
Phoradendron coryae	1	7	25
Lycium exsertum	t	14	5
Ceanothus greggii	t	12	13
Acacia greggii	t	12	4
Cercidium microphyllum	t	9	t
Phoradendron californicum	t	9	t
Quercus turbinella	t	7	6
Dwarf Shrubs & Half-Shrubs	26	95	92
Calliandra eriophylla	14	84	92
Eriogonum spp.	8	80	46
Aplopappus laricifolius	4	30	52
Janusia gracilis	t	14	4
Krameria parvifolia	t	9	4
Sphaeralcea spp.	t	7	6
Lotus rigidus	t	3	7
Forbs	5	75	31
Euphorbia spp.	2	36	14
Ferns spp.	1	16	22
Echeveria collomae	1	7	28
Artemisia ludoviciana	t	14	3
Erodium cicutarium	t	12	6
Franseria confertiflora	t	12	3
Menodora scoparia	t	5	10
Aggregate, 16 spp.	1	3-5	19
Grasses	5	68	63
Miscellaneous	1	11	28
Opuntia spp. fruit	1	7	14
Yucca baccata fruit	t	3	28
Simmondsia chinensis fruit	t	3	26
Total	100	100	-

Table 10. Late fall contents of 64 mule deer stomachs (22 Nov. - 1 Dec. 1963), following a wet summer.

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	49	100	94
Calliandra eriophylla	39	91	94
Eriogonum spp.	5	70	33
Sphaeralcea spp.	3	59	26
Aplopappus laricifolius	2	33	26
Janusia gracilis	t	14	5
Porophyllum gracile	t	11	1
Solanum xanti	t	8	16
Krameria parvifolia	t	5	t
Lotus rigidus	t	3	2
Tall Shrubs, Browse Parts Only	25	97	79
Simmondsia chinensis	20	94	79
Cercocarpus betuloides	2	20	27
Rhus ovata	2	12	36
Phoradendron californicum	1	6	31
Prosopis juliflora	t	16	26
Acacia greggii	t	9	t
Rhamnus crocea	t	8	11
Ceanothus greggii	t	8	3
Forbs	20	97	70
Euphorbia spp.	12	95	65
Artemisia ludoviciana	4	36	47
Franseria confertiflora	1	44	26
Euphorbia incisa	1	33	10
Cuscuta spp.	t	11	23
Tradescantia occidentalis	1	2	62
Erodium cicutarium	t	11	5
Menodora scoparia	t	11	4
Ferns spp.	t	5	21
Aggregate, 7 spp.	1	2-5	36
Grasses	6	72	56
Shrub Fruits (*Simmondsia chinensis*)	t	2	5
Total	100	100	-

Table 11. Late fall contents of 29 mule deer stomachs (27-29 Nov. 1964), following a wet summer and early frosts.

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	45	100	95
Calliandra eriophylla	20	86	58
Eriogonum spp.	14	93	85
Janusia gracilis	5	38	26
Aplopappus laricifolius	3	31	27
Brickellia spp.	3	14	24
Porophyllum gracile	t	24	6
Sphaeralcea spp.	t	7	t
Tall Shrubs, Browse Parts Only	32	100	74
Simmondsia chinensis	24	90	74
Phoradendron californicum	3	24	23
Rhamnus crocea	3	17	29
Cercocarpus betuloides	1	24	18
Rhus ovata	1	10	19
Acacia greggii	t	14	6
Ceanothus greggii	t	10	7
Prosopis juliflora	t	10	3
Rhus trilobata	t	3	15
Quercus turbinella	t	7	1
Forbs	22	100	77
Artemisia ludoviciana	12	38	77
Euphorbia spp.	6	79	18
Ferns spp.	1	34	7
Franseria confertiflora	t	14	6
Margaranthus solanaceus	t	10	4
Gutierrezia sarothrae	t	10	1
Mirabilis bigelovii	t	7	2
Aggregate, 14 spp.	3	3	26
Shrub Fruits (*Simmondsia chinensis*)	1	21	8
Grasses	t	52	5
Total	100	100	-

Table 12. Midwinter contents of 12 white-tailed deer stomachs (10-16 Jan. 1966, 1968).

Food	Average volume	Occur-rence	Greatest volume per sample
	%	%	%
Tall Shrubs, Browse Parts Only	43	92	97
Ceanothus greggii	19	75	65
Rhamnus crocea	15	83	60
Cercocarpus betuloides	5	67	15
Rhus ovata	4	25	28
Phoradendron californicum	t	16	6
Lonicera interrupta	t	8	6
Forbs	27	100	46
Dichelostemma pulchellum	7	58	21
Euphorbia spp.	6	75	18
Artemisia ludoviciana	4	67	23
Lupinus spp.	4	50	29
Erodium cicutarium	2	50	7
Franseria confertiflora	1	50	6
Cheilanthes fendleri	1	8	10
Pellaea longimucronata	1	8	9
Penstemon linarioides	1	8	8
Dwarf Shrubs & Half-Shrubs	25	100	82
Eriogonum spp.	18	92	65
Calliandra eriophylla	7	58	38
Grasses	5	58	36
Bromus rubens	4	58	36
Grass spp.	1	58	4
Total	100	100	-

Table 13. Midwinter contents of 10 mule deer stomachs (10-16 Jan. 1966, 1968).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Tall Shrubs, Browse Parts Only	39	100	61
Simmondsia chinensis	20	90	52
Cercocarpus betuloides	8	80	21
Ceanothus greggii	4	50	18
Rhamnus crocea	3	40	22
Rhus ovata	3	30	15
Quercus turbinella	1	10	7
Dwarf Shrubs & Half-Shrubs	36	100	69
Eriogonum spp.	33	100	54
Calliandra eriophylla	3	90	15
Forbs	21	100	34
Dichelostemma pulchellum	11	90	23
Artemisia ludoviciana	2	40	9
Erodium cicutarium	2	30	15
Lupinus spp.	2	30	9
Euphorbia spp.	1	40	6
Pellaea longimucronata	1	40	6
Lygodesmia spp.	1	30	4
Franseria confertiflora	1	20	5
Gutierrezia sarothrae	t	20	2
Tradescantia occidentalis	t	20	2
Lotus spp.	t	20	1
Mirabilis bigelovii	t	20	1
Grasses	4	90	8
Grass spp.	3	90	5
Bromus rubens	1	30	7
Poa spp.	t	20	2
Total	100	100	-

Table 14. Contents of 5 white-tailed deer stomachs before winter leaf-drop of calliandra (28-31 Dec. 1966).

Food	Average volume	Occur-rence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	39	100	75
Calliandra eriophylla	27	100	59
Eriogonum spp.	12	80	16
Forbs	28	100	45
Artemisia ludoviciana	17	80	35
Euphorbia spp.	6	60	17
Physalis spp.	3	40	8
Cuscuta spp.	1	20	4
Echeveria collomae	1	20	4
Shrub Fruits	16	40	73
Acacia greggii dried pods	16	40	73
Tall Shrubs, Browse Parts Only	12	100	41
Rhamnus crocea	6	40	30
Cercocarpus betuloides	4	80	11
Ceanothus greggii	2	100	8
Grasses	5	80	23
Bromus rubens	5	80	23
Total	100	100	-

Table 15. Contents of 10 mule deer stomachs before winter leaf-drop of calliandra (28-31 Dec. 1966).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	59	100	80
Calliandra eriophylla	42	90	74
Eriogonum spp.	15	90	49
Sphaeralcea spp.	2	50	8
Forbs	26	100	49
Euphorbia spp.	17	100	40
Artemisia ludoviciana	8	90	19
Echeveria collomae	1	10	.9
Cuscuta spp.	t	20	2
Tall Shrubs, Browse Parts Only	8	90	37
Simmondsia chinensis	6	90	34
Rhus ovata	1	30	8
Ceanothus greggii	1	20	4
Acacia greggii	t	30	2
Phoradendron californicum	t	10	5
Grasses	6	70	28
Bromus rubens	6	60	28
Grass spp.	t	40	2
Shrub Fruits	1	20	8
Simmondsia chinensis	1	10	8
Acacia greggii	t	20	t
Total	100	100	-

Table 16. Late winter contents of 14 white-tailed deer stomachs 26 Feb. - 24 March 1960, 1962-1964, 1967).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Forbs	40	100	96
Dichelostemma pulchellum	14	64	49
Artemisia ludoviciana	9	50	41
Erodium cicutarium	4	29	42
Psoralea spp.	4	21	29
Verbena spp.	2	7	32
Echeveria collomae	1	21	16
Eschsholtzia mexicana	1	21	12
Lupinus spp.	1	21	4
Lotus humistratus	1	7	13
Solanaceae spp.	1	7	12
Tradescantia occidentalis	1	7	12
Marah gilensis	1	7	11
Euphorbia spp.	t	29	5
Erigeron divergens	t	21	3
Erysimum capitatum	t	14	4
Lygodesmia spp.	t	14	1
Anemone tuberosa	t	14	t
Microsteris gracilis	t	14	t
Lathyrus graminifolium	t	7	7
Unidentified Forbs, 4 spp.	t	7	5
Tall Shrubs, Browse Parts Only	40	64	86
Cercocarpus betuloides	15	86	48
Rhamnus crocea	9	57	34
Rhus ovata	4	36	27
Lonicera interrupta	4	14	54
Quercus turbinella	3	36	23
Ceanothus integerrimus	2	14	25
Ceanothus greggii	1	29	5
Arctostaphylos pungens	1	21	8
Quercus emoryi	1	7	10
Garrya flavescens	t	7	8
Dwarf Shrubs & Half Shrubs	10	93	26
Eriogonum spp.	6	86	22
Calliandra eriophylla	3	43	13
Lotus rigidus	1	14	16
Grasses	10	86	44
Grass spp.	6	64	44
Bromus rubens	4	29	40
Total	100	100	-

Table 17. Late winter contents of 10 mule deer stomachs (27 Feb - 27 March 1962-1964, 1967-1968).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Forbs	45	90	85
Dichelostemma pulchellum	13	60	43
Erodium cicutarium	10	40	85
Lotus spp., annual	6	20	26
Arabis perennans	5	20	44
Anemone tuberosa	4	20	35
Lupinus spp.	2	40	5
Artemisia ludoviciana	2	30	12
Euphorbia spp.	2	30	8
Compositae spp.	1	10	10
Pseudocymopterus montanus	t	20	1
Lygodesmia spp.	t	10	5
Plantago spp.	t	10	5
Dwarf Shrubs & Half Shrubs	28	90	55
Eriogonum spp.	13	100	30
Lotus rigidus	8	4	42
Calliandra eriophylla	3	7	13
Sphaeralcea spp.	2	20	25
Aplopappus laricifolius	2	20	18
Tall Shrubs, Browse Parts Only	25	90	61
Simmondsia chinensis	23	80	61
Ceanothus greggii	2	20	18
Quercus turbinella	t	20	1
Grasses	2	90	6
Grass spp.	1	90	5
Bromus rubens	1	20	6
Total	100	100	-

Table 18. Late spring contents of 11 white-tailed deer stomachs (11-18 May 1965-1967).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Tall Shrubs, Browse Parts Only	45	100	91
Rhus ovata immature leaves	16	73	54
Ceanothus integerrimus	9	36	43
Rhamnus crocea	6	73	19
Quercus turbinella	6	36	3
Ceanothus greggii	5	100	13
Garrya flavescens	2	36	11
Rhus trilobata	1	55	4
Acacia greggii	t	27	2
Dwarf Shrubs & Half-Shrubs	31	91	65
Calliandra eriophylla	12	73	38
Krameria parvifolia	12	73	33
Solanum xanti fruit	4	55	26
Solanum xanti leaf, stem	3	55	13
Dyssodia porophylloides	t	9	6
Eriogonum spp.	t	18	t
Forbs	10	91	38
Cuscuta spp.	7	45	33
Artemisia ludoviciana	1	55	3
Euphorbia spp.	1	45	4
Comandra pallida	1	36	5
Abutilon spp.	t	18	6
Cruciferae spp.	t	18	t
Shrub Fruits	9	64	37
Garrya flavescens enlarged galls	5	18	35
Rhus trilobata	3	55	14
Ceanothus integerrimus	1	9	13
Yucca baccata flower & stalk	5	27	38
Grasses	t	55	1
Grass spp.	t	36	1
Bromus rubens	t	18	1
Total	100	100	-

Table 19. Late spring contents of 11 mule deer stomachs (10-24 May 1965-1967).

Food	Average volume	Occurrence	Greatest volume per sample
	%	%	%
Dwarf Shrubs & Half-Shrubs	33	100	73
Calliandra eriophylla	24	100	65
Krameria parvifolia	9	91	22
Eriogonum spp.	t	55	3
Forbs	24	100	71
Psoralea spp.	6	27	45
Euphorbia spp.	4	100	13
Calochortus kennedyi	3	36	18
Menodora scoparia	3	33	20
Abutilon spp.	2	27	12
Lupinus succulentus	2	9	21
Cuscuta spp.	1	64	7
Artemisia ludoviciana	1	27	13
Lygodesmia spp.	1	18	9
Marah gilensis	1	9	6
Tall Shrubs, Browse Parts Only	24	100	56
Simmondsia chinensis	12	91	26
Rhus ovata	6	36	46
Ceanothus greggii	4	64	14
Cercidium floridum	2	18	12
Rhamnus crocea	t	27	3
Miscellaneous	10	36	38
Nolina microcarpa sprouts & buds	6	27	32
Yucca baccata flower & stalk	4	9	38
Shrub Fruits	9	54	63
Simmondsia chinensis	7	27	63
Ceanothus greggii	2	18	13
Grasses	t	64	4
Bromus rubens	t	36	2
Grass spp.	t	36	2
Total	100	100	-

Table 20. Plant species present in one or more of 368 deer stomachs, Three Bar area, March 1960-January 1970[1].

W = occurred in white-tailed deer sample
M = occurred in mule deer sample

		Botanical Name	Non-Technical Name
W	M	Abutilon parvulum	Indian-mallow
W		Acacia angustissima	Whiteball Acacia
	M	Acacia constricta	Whitethorn Acacia
W	M	Acacia greggii	Catclaw Acacia
W	M	Acalypha neomexicana	Acalypha
	M	Allionia incarnata	Trailing Four O'Clock
	M	Amsinckia intermedia	Fiddleneck
	M	Anemone tuberosa	Anemone
	M	Aplopappus laricifolius	Turpentine-bush
	M	Arabis perennans	Rockcress
W		Arctostaphylos pungens	Manzanita
	M	Arenaria douglasii	Sandwort
W		Artemisia dracunculoides	False Tarragon
W	M	Artemisia ludoviciana	Artemisia
W	M	Astragalus lentiginosus	Locoweed

1/ This list includes plants observed in 74 white-tailed and 212 mule deer samples described elsewhere in this report (Figures 1-10; Tables 1-19), and in 9 white-tailed and 73 mule deer samples which were not reported. The latter were too small (47 each); or were analyzed after data from the other samples were compiled (22 each); or were from odd sites or seasons (13 each) which did not conform to categories of time and place established for tabulations in the major part of this report.

Table 20. (continued)

W		*Ayenia filiformis*	Ayenia
	M	*Baileya multiradiata*	Baileya
	M	*Bouteloua curtipendula*	Sideoats Grama
	M	*Brickellia californica*	Brickellia
W	M	*Bromus rubens*	Red Brome
W	M	*Calliandra eriophylla*	Calliandra
W	M	*Calochortus kennedyi*	Desert Mariposa
W		*Carex* spp.	Sedge
	M	*Carnegiea gigantea*	Saguaro
W	M	*Ceanothus greggii*	Desert Ceanothus
W		*Ceanothus integerrimus*	Bigleaf Ceanothus
W	M	*Celtis reticulata*	Hackberry
	M	*Cercidium floridum*	Blue Paloverde
	M	*Cercidium microphyllum*	Yellow Paloverde
W	M	*Cercocarpus betuloides*	Birchleaf Mountain-mahogany
W	M	*Cheilanthes fendleri*	Lip Fern
W		*Cirsium neomexicanum*	Thistle
	M	*Clematis ligusticifolia*	Clematis
W	M	*Comandra pallida*	Bastard Toadflax
W		*Convolvulus linearilobus*	Narrow-leaved Bindweed
W	M	*Cuscuta* spp.	Dodder
W		*Dalea albiflora*	Dalea
	M	*Dalea formosa*	Dalea
	M	*Dasylirion wheeleri*	Sotol
W	M	*Dichelostemma pulchellum*	Grass-nuts
W	M	*Dyssodia porophylloides*	Dyssodia

Table 20. (continued)

W	M	Echeveria collomae	Echeveria
	M	Encelia farinosa	Brittlebush
	M	Encelia frutescens	Encelia
W	M	Eriastrum diffusum	Eriastrum
	M	Eriodictyon angustifolium	Yerba Santa
	M	Eriogonum fasciculatum	Eriogonum
W		Eriogonum jamesii	Eriogonum
W	M	Eriogonum wrightii	Eriogonum
W	M	Erodium cicutarium	Filaree
	M	Erodium texanum	Filaree
W	M	Eschscholtzia mexicana	Mexican Goldpoppy
	M	Euphorbia capitellata	Spurge
W		Euphorbia florida	Spurge
W	M	Euphorbia incisa	Spurge
W	M	Euphorbia melanadenia	Spurge
W		Evolvulus arizonicus	Evolvulus
W		Ferocactus wislizeni	Barrel Cactus
W	M	Ferns, spp. unidentified	Ferns
	M	Fouquieria splendens	Ocotillo
W	M	Franseria confertiflora	Bur-sage
	M	Funastrum heterophyllum	Vine Milkweed
W		Garrya flavescens	Yellow-leaf Silktassel
W		Garrya wrightii	Wright Silktassel
W		Gilia aggregata	Gilia

Table 20. (continued)

W	M	<u>Gnaphalium wrightii</u>	Cudweed
W	M	<u>Gutierrezia sarothrae</u>	Snakeweed
	M	<u>Hilaria belangeri</u>	Curly Mesquite-grass
W	M	<u>Ipomoea coccinea</u>	Redstar Morning-glory
W		<u>Ipomoea hirsutula</u>	Morning-glory
	M	<u>Janusia gracilis</u>	Janusia
W		<u>Juniperus deppeana</u>	Alligator Juniper
	M	<u>Juniperus monosperma</u>	Oneseed Juniper
W	M	<u>Krameria parvifolia</u>	Ratany
W		<u>Linum lewisii</u>	Flax
W		<u>Lonicera interrupta</u>	Honeysuckle
W	M	<u>Lotus rigidus</u>	Desert Deervetch
	M	<u>Lotus salsuginosus</u>	Deervetch
	M	<u>Lotus tomentellus</u>	Deervetch
W	M	<u>Lupinus concinnus</u>	Lupine
W	M	<u>Lupinus succulentus</u>	Lupine
	M	<u>Lycium exsertum</u>	Wolfberry
W	M	<u>Lygodesmia juncea</u>	Skeletonplant
	M	<u>Marah gilensis</u>	Marah
W	M	<u>Margaranthus solanaceus</u>	Margaranthus
	M	<u>Marrubium vulgare</u>	Hoarhound
W	M	<u>Maurandya antirrhiniflora</u>	False Snapdragon
W	M	<u>Melampodium leucanthum</u>	Blackfoot
	M	<u>Melilotus officinalis</u>	Yellow Sweetclover

Table 20. (continued)

	M	*Menodora scoparia*	Menodora
W		*Mentzelia pumila*	Stickleaf
W	M	*Mimosa biuncifera*	Catclaw Mimosa
W		*Mimulus guttatus*	Monkey-flower
W	M	*Mirabilis bigelovii*	Four O'Clock
	M	*Nolina microcarpa*	Nolina
	M	*Notholaena sinuata*	Cloak Fern
	M	*Notholaena standleyi*	Cloak Fern
	M	*Oenothera hookeri*	Evening-Primrose
	M	*Opuntia engelmannii*	Desert Prickly-pear
	M	*Orthocarpus purpurascens*	Owl-clover
W	M	*Pellaea longimucronata*	Cliff-brake
W	M	*Penstemon linarioides*	Penstemon
W		*Penstemon* spp.	Penstemon
	M	*Phlox tenuifolia*	Vine Phlox
W	M	*Phoradendron californicum*	Mistletoe
W	M	*Phoradendron coryae*	Mistletoe
W	M	*Physalis fendleri*	Groundcherry
W		*Pinus ponderosa*	Ponderosa pine
	M	*Plantago purshii*	Indianwheat
W	M	*Poa bigelovii*	Mutton Bluegrass
W	M	*Poa* spp.	Bluegrass
	M	*Populus fremontii*	Cottonwood
	M	*Porophyllum gracile*	Deerweed

Table 20. (continued)

W	M	Prosopis juliflora	Mesquite
W		Prunus virens	Chokecherry
	M	Pseudocymopterus montanus	Pseudocymopterus
	M	Psoralea spp.	Scurf-pea
W		Quercus arizonica	Arizona Oak
W	M	Quercus emoryi	Emory Oak
W	M	Quercus turbinella	Turbinella Oak
W	M	Rhamnus crocea	Holly-leaf Buckthorn
W	M	Rhus ovata	Sugar Sumac
W	M	Rhus trilobata	Skunkbush
	M	Selaginella arizonica	Resurrection Plant
W	M	Simmondsia chinensis	Jojoba
W	M	Solanum xanti	Purple Nightshade
W	M	Solanum spp.	Nightshade
	M	Solidago missouriensis	Goldenrod
W	M	Sphaeralcea ambigua	Globemallow
W	M	Sphaeralcea spp.	Globemallow
W		Thysanocarpus amplectens	Lacepod
W	M	Tradescantia occidentalis	Spiderwort
W	M	Yucca baccata	Yucca

SUMMARY

Stomach contents were examined from 83 white-tailed and 285 mule deer taken on the Three Bar Wildlife Area, 1960-1970. The deer did not select a pure diet of any one kind of food in any season. Major foods were forbs, dwarf shrubs and half-shrubs, mast and other fruits, and evergreen browse of both chaparral and desert zones. In most seasons, evergreen browse was less preferred than other foods, but it was important because of stability of supply during dry years and the regular seasonal declines of other forage stands. Some of the least preferred browse plants were important because of their fruit crops.

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Part II: Chemical Analyses and In Vitro Digestibility of Seasonal Deer Forages

by Philip J. Urness

INTRODUCTION

Restrictions on forage quality and quantity, aggravated by drought, have generally been accepted as the primary factors limiting deer populations in central Arizona (Hanson and McCulloch 1955; Swank 1956, 1958). This view was based on nutritional analyses emphasizing proximate fractions of preferred browse forages which showed undesirably low levels of protein and phosphorus during shrub dormancy. Reynolds (1967) showed similar low levels in dormant chaparral fire sprouts.

Browse, especially leaves, is important to deer diets, but McCulloch (1967, 1972) has shown that significant amounts of herbaceous forages and various fruits are also consumed. This study evaluated critical nutritional parameters for most plant materials eaten by mule deer and Coues white-tailed deer at Three Bar. The objective of a more complete analysis was to provide a better understanding of how nutritional factors affect deer reproduction and survival.

METHODS

Species found in deer diets during six distinct feeding periods (McCulloch Part I) were analyzed for nutritional values. All major and many minor forage species were collected to nearly approximate total seasonal intake. Composite samples of individual forages were hand-clipped from 20 or more randomly selected plants, weighed green, oven-dried to constant weight at 100°C, and analyzed for crude protein, phosphorus, calcium (AOAC 1965), and acid-detergent fiber (Van Soest 1966). Terminal 4-inch segments of new-growth twigs were taken from shrubs, with leaves and stems analyzed separately; herbaceous species were sampled as whole plants excluding roots. Some shrub and cactus fruits presented difficulties in analysis because of insoluble oils and resistance to drying, but nutritional values of these important mid- and late-summer foods were estimated with reasonable precision.

In vitro techniques developed by Tilley and Terry (1963) proved useful in rapidly obtaining digestibility coefficients for large numbers of forage samples. Deer, collected in the general area and time of plant sampling, provided rumen microorganism inocula. Entire rumen contents were taken in anaerobic conditions to the laboratory, where the liquid fraction was separated from coarse solids with cheesecloth, diluted with buffer solution to pH6.2, and injected into prepared digestion flasks. Triplicate half-gram forage samples were fermented at 39°C for 48 hours, followed by a 48-hour acid : pepsin phase which killed all microorganisms and simulated enzymatic function in the lower digestive tract. Digestion coefficients were calculated by subtracting residual dry weight from original sample dry weight corrected for inocula dry weight. A FORTRAN program developed by Pearson (1970) expedited computations.

RESULTS AND DISCUSSION

Nutrient content percentages and digestibility coefficients for individual forage species are presented in Tables 1-6. Although nutrient factors vary a great deal in seasonally important deer forages, several significant patterns emerge. First, some good quality forages are available in quantity to Three Bar deer during each feeding period in the annual cycle. Secondly, few forage species supply a good balance of most nutrients individually, although forbs as a class are nutritionally superior to browse leaves on a dry weight basis. Finally, the better forbs, because of low dry-matter content and scattered distribution, usually provide important supplementary nutrients, but the bulk of the deer diet comes from abundant browse and lower quality forbs.

Consumption and nutritional value of central Arizona deer forages are primarily influenced by phenological development. Although many browse plants retain green leaves yearlong, deer depend more heavily upon them either during active growth periods or when more attractive forages are unavailable. Forbs and grasses developing twice yearly, after effective winter and midsummer precipitation, greatly affect intake, as do ripening woody plant fruits in midsummer. Discussion will, therefore, emphasize six feeding periods of distinctly different phenology; May-June, July-September, October, November-December, January, and February-April (Fig. 3, Part I).

General standards can be given to judge adequacy of nutrient levels in individual forages tested in this study, provided undue emphasis is not placed on single factors. That is, plants poor in protein may be good sources of phosphorus, energy, or some other factor. It is, of course, the collective intake of particular nutrients in the total diet that is critical. The standards are a useful comparative measure among species, however, and they are offered for that purpose; authorities for these values were cited previously (Urness, Green and Watkins 1971) and elsewhere in Parts II and III.

	Range of Nutrient Percentages			
Nutrient Factor	Excellent	Good	Fair	Poor
Protein	> 12	10–12	7–10	< 7
Phosphorus	>.30	.25–.30	.16–.25	<.16
Calcium[1]	.20–.50	.50–1.00	1.00–1.50	>1.50
Acid-Detergent Fiber	> 30	30–40	40–50	>50
In Vitro Digestibility	> 50	40–50	30–40	30
P:Ca Ratio	2:1–1:2	1:2–1:3	1:3–1:5	1:>5

[1] Excessive calcium inhibits phosphorus metabolism, and the minimum requirement for calcium is low (abour .10 percent). Most southwest deer forages are high in calcium.

May-June. Browse was an important dietary item during late spring, since most cold-season forbs and grasses have matured while shrub growth, sustained by deeper soil moisture, continues well into the dry period. New leaves of many abundant shrubs such as turbinella oak *(Quercus turbinella)*, calliandra *(Calliandra eriophylla)*, desert ceanothus *(Ceanothus greggii)*, bigleaf ceanothus *(C. integerrimus)* and ratany *(Krameria parvifolia)* have high protein levels, moderate to low fiber and calcium content, and some are high in phosphorus (Table 1).

Fruits of jojoba *(Simmondsia chinensis)*, desert ceanothus, and purple nightshade *(Solanum xanti)* are available by mid-May. The latter are good sources of phosphorus and are highly digestible. Yucca *(Yucca baccata)* flower stalks are attractive to mule deer, form an excellent source of phosphorus, and are highly digestible.

Several desert forbs remain important forages for mule deer into late spring. The four most prominent, scurf-pea *(Psoralea* sp.), spurge *(Euphorbia melanadenia)*, desert mariposa *(Calochortus kennedyi)*, and menodora *(Menodora scoparia)* are generally lower in most nutrients than early spring forbs. White-tailed deer use forbs lightly in late spring, but two species, dodder *(Cuscuta sp.)* and purple nightshade fruits, have desirably narrow phosphorus:calcium ratios in the range of 2:1 to 1:2 (Dietz et al. 1962:53).

July-September. Woody plant fruits, which dominate midsummer deer diets, have high phosphorus content and generally narrow P:Ca ratios (Table 2). They are extremely valuable at this time because other forages tend to be low in phosphorus or have wide P:Ca ratios. Mesquite *(Prosopis juliflora)* and catclaw acacia *(Acacia greggii)* pods, both high in protein, and turbinella oak acorns are heavily used by mule deer. Acorns are poor protein sources, but other studies have shown them to be energy-rich concentrates (Goodrum 1959). Saguaro *(Carnegiea gigantea)* fruits, although taken in small amounts, are high in protein, digestibility, and phosphorus, and desirably low in calcium. Desert prickly-pear *(Opuntia engelmannii)* fruits are not nearly so valuable as those of saguaro, yet are taken in about equal quantity. Prickly-pear fruits were more available during deer collection periods, which probably did not coincide with peak availability of saguaro fruits.

Some shrub leaves remain high in protein during midsummer, but calcium increases and phosphorus declines with maturity. Occasional new growth following summer rains likely provides better quality browse, although no comparative tests of new vs. older growth were made. McCulloch (1967) demonstrated significant differences in crude protein between spring leaves and late summer leaves of jojoba collected the following January.

October. Protein content of browse leaves is moderate to high during the dry fall period, but acid-detergent fiber increases with a corresponding decline in digestibility (Table 3). In addition, phosphorus:calcium ratios widen in most species.

Palatable forbs are largely unavailable to mule deer in desert types during October, but herbaceous forages and browse are about equally important in white-tailed deer diets in chaparral. Protein and digestibility of most forbs are high at this time, but phosphorus:calcium ratios become undesirably wide in autumn.

November-December. Forages available to desert mule deer during late fall-early winter are collectively poorer than other periods, but, with the possible exception of phosphorus, nutrient levels are more than adequate for maintenance (Table 4). Most browse species contain less protein and phosphorus than they did in early fall. Calcium and fiber levels increase generally while digestibility declines. Forb use by mule deer increases somewhat, but the two main species, spurge and artemisia *(Artemisia ludoviciana)*, are low in protein and have wide P:Ca ratios.

White-tailed deer forages also exhibit lower nutrient levels, with some notable exceptions. Calliandra and bigleaf ceanothus are the important browse species. Leaves of the latter are high in protein and digestibility, low in fiber. Several herbaceous species, including red brome *(Bromus rubens)*, filaree *(Erodium cicutarium)*, and margaranthus *(Margaranthus solanaceus)*, are taken in small amounts but provide excellent sources of protein and phosphorus. All but red brome have wide P:Ca ratios. In view of red brome's apparent nutritional value and abundance, the fact that it receives light use poses an interesting question since new

growth of many cool-season grasses is avidly sought by deer in other locations (Dietz et al. 1962, Leach 1956, McCulloch 1968, Urness 1966).

January. Browse species, comprising more than two-thirds of both deer species diets, retain about the same protein levels as in early winter (averaging 9 percent) but show further declines in phosphorus (from .20 to .14 percent). Availability of high-quality cool-season herbaceous forages, including grass-nuts *(Dichelostemma pulchellum)*, filaree, lupine *(Lupinus succulentus)*, and red brome, improve overall nutrient intake, especially for phosphorus (Table 5). Fiber remains relatively high in most browse species and some forbs, with corresponding low digestibility. Exceptions are jojoba leaves, filaree, and grass-nuts. The latter is eaten in quantity and is in every respect a superlative forage.

Paradoxically, eriogonum *(Eriogonum wrightii)* is used heavily by both deer species, yet is very low in protein, phosphorus, and digestibility, high in fiber and dry matter. It was eaten in quantity and rated by Nichol (1938) as one of the most important browse plants in southern Arizona. Obviously other factors than those we measured influence preference.

February-April. Analyses of browse species in early spring showed generally slight increases in nutritive value over midwinter. The four most heavily used species — jojoba, birchleaf mountain-mahogany *(Cercocarpus betuloides)*, eriogonum, and holly-leaf buckthorn — changed the least (Table 6). New leaves of bigleaf ceanothus are high in protein and digestibility, but perhaps because of limited availability are eaten in small amounts by white-tailed deer. Turpentine-bush *(Aplopappus laricifolius)* is used lightly by mule deer, but has moderately high protein content and an unusually high digestibility.

Early spring is for deer the nutritional high point of the year because abundant cool-season forbs provide exceptionally high-quality forage. Most herbaceous plants were high in protein, phosphorus, and digestibility but low in fiber. Calcium tended to be excessive relative to phosphorus, but there are notable exceptions including grass-nuts, anemone *(Anemone tuberosa)*, and marah *(Marah gilensis)*. Marah had the highest crude protein content of any forage tested at the Rapid City Lab. (Dietz, personal comm.).

Table 1. Chemical analyses and in vitro digestibility for May-June forages (percent).

Plant species	Plant collection date	Plant[1/] part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	Dry matter	In vitro digestibility (Dry matter disappearance) Mule deer	White-tailed deer
Browse									
Calliandra eriophylla	5-4-67	LE	15	37	.91	.20	45	28	20
Ceanothus greggii	"	LE	15	35	.82	.27	38[2/]	48	31
		ST	8	46	.74	.25		48	30
	5-8-69	FR	12	39	.63	.21	32	43	
Ceanothus integerrimus	5-4-67	LE	23	34	1.33	.34	29		33
		ST	9	43	1.50	.26			29
Garrya flavescens	"	LE	8	40	.95	.30	33		36
		ST	5	33					42
Krameria parvifolia	"	LE	14	43	.72	.46	39	40	31
Nolina microcarpa	"	LE	4	55	.62	.16	53	26	
Quercus turbinella	"	LE	13	38	.43	.32	33		33
		ST	9	37	.49	.24			31
Rhamnus crocea	"	LE	10	39	1.84	.12	52	58	27
		ST	7	44	1.03	.10			24
Rhus ovata	"	LE	6	37	1.04	.22	49	38	33
		ST	5	44	1.12	.16		33	28
Simmondsia chinensis	"	LE	10	26	.57	.20	39	47	
		ST	10	41	.31	.25		47	
		FR	11	40	.79	.20	31	46	
Yucca baccata	"	FL	11	24	.40	.46	14	75	
Forbs									
Calochortus kennedyi	"	WP	9	37	.83	.32	19	56	
Cuscuta sp.	"	WP	8	19	.14	.22	30	71	64
Euphorbia melanadenia	"	WP	6	28	.95	.28	50	62	
Lupinus succulentus	"	WP	14	38	1.17	.35	20	63	
Marah gilensis	5-8-69	WP	16	29	2.68	.43	13	52	
Menodora scoparia	5-4-67	WP	9	42	.95	.23	46	46	
Psoralea sp.	5-8-69	WP	16	28	1.75	.24	30	64	
Solanum xanti	5-4-67	WP	12	36	.95	.34	28		51
		FR	5	21	.20	.32	18		61

1/ LE = Leaves, ST = Stems, FR = Fruit, FL = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

Table 2. Chemical analyses and in vitro digestibility for July-September forages (percent),

Plant species	Plant collection date	Plant[1/] part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	In vitro digestibility (Dry matter disappearance) Dry matter	Mule deer	White-tailed deer
Browse									
Acacia greggii	6-28-67	FR	15	35	.70	.28	41	32	29
Calliandra eriophylla	"	LE	14	34	1.19	.22	54	32	
Carnegiea gigantea	"	FR	13	31	.31	.34	20	64	
Ceanothus integerrimus	"	LE	15	32	1.65	.17	48[2/]		54
		ST	10	56	1.11	.13			29
Garrya flavescens	"	FR	7	56	.61	.29	96		31
Opuntia engelmannii	"	FR	9	29	2.53	.26	19	49	
Prosopis juliflora	"	FR	17	35	.77	.25	39	54	51
Quercus emoryi	"	FR	6	58	.35	.13	52		30
Quercus turbinella	"	LE	11	51	.57	.21	46	35	41
		ST	8					35	34
		FR	6	29	.66	.16	36	35	34
Rhamnus crocea	"	LE	9	51	1.32	.15	53		33
		ST	4	51	1.01	.16			27
Rhus trilobata	"	FR	9	35	.22	.35	91		40
Simmondsia chinensis	"	LE	20	24	.85	.16	40	43	
		ST	9	38	.72	.21		35	
		FR	12	49	.22	.23	42	44	
Forbs									
Artemisia ludoviciana	"	WP	9	44	.64	.32	51		27
Psoralea sp.	5-16-67	WP	20	42	1.80	.27	33	53	

1/ LE = Leaves, ST = Stems, FR = Fruit, F_L = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

Table 3. Chemical analyses and in vitro digestibility for October forages (percent).

Plant species	Plant collection date	Plant[1/] part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	Dry matter	In vitro digestibility (Dry matter disappearance) Mule deer	White-tailed deer
Browse									
Calliandra eriophylla	9-25-67	LE	13	38	1.30	.29	59	33	32
Ceanothus greggii	"	LE	12	49	.67	.25	52[2/]	37	39
		ST	5	73	.43	.12		29	26
Ceanothus integerrimus	"	LE	16	33	2.47	.16	44		58
		ST	8	58	1.27	.13			
Cercocarpus betuloides	"	LE	13	53	1.66	.14	55	33	32
		ST	5	74	1.12	.16		25	25
Eriogonum wrightii	"	WP	8	51	.94	.15	48		24
Gutierrezia sarothrae	"	WP	10	40	1.42	.20	51	45	53
Quercus arizonica	"	FR	4	43	.80	.34	46		
Rhamnus crocea	"	LE	10	45	.51	.12	49	36	40
		ST	4	61	.98	.16		43	38
Rhus trilobata	10-1-69	LE	9	46	1.19	.33	48		31
		ST	3	56	.80	.11			30
Simmondsia chinensis	9-25-67	LE	13	34	.93	.17	41	40	
		ST	8	49	.87	.15		30	
Forbs									
Artemisia ludoviciana	"	WP	9	44	.44	.27	53	33	53
Euphorbia melanadenia	"	WP	7	28	1.10	.23	55	65	61
Franseria confertiflora	"	WP	17	42	2.10	.34	36		53
Ipomoea coccinea	"	WP	15	45	1.38	.19	21		66
Margaranthus solanaceus	10-1-69	WP	13	32	1.82	.25	26		63
Mentzelia pumila	"	WP	9	36	1.61	.24	27		60
Porophyllum gracile	9-25-67	WP	7	44	2.30	.20	40	44	
Solanum xanti	10-1-69	WP	19	26	1.65	.27	31		61

1/ LE = Leaves, ST = Stems, FR = Fruit, FL = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

Table 4. Chemical analyses and in vitro digestibility for November-December forages (percent).

Plant species	Plant collection date	Plant[1/] part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	Dry matter	In vitro digestibility (Dry matter disappearance) Mule deer	White-tailed deer
Browse									
Acacia greggii	12-1-69	LE	10	50	2.66	.11	50		28
Aplopappus laricifolius	11-27-67	WP	8	51	1.33	.20	49	55	
Calliandra eriophylla	"	LE	11	45	2.04	.14	51	27	31
Ceanothus greggii	"	LE	9	29	1.69	.15	56[2/]		45
		ST	8	56	1.06	.10			38
Ceanothus integerrimus	"	LE	14	22	2.63	.14	44		61
		ST	9	43	1.44	.11			45
Cercocarpus betuloides	"	LE	10	46	1.76	.15	55	31	29
		ST	6	54	.99	.11		24	23
Eriogonum wrightii	"	WP	5	50	1.00	.15	47	16	27
Garrya flavescens	"	LE	5	41	1.05	.49	52		58
		ST	-	-	-	-	-	-	46
Lonicera interrupta	12-1-69	LE	8	28	2.00	.30	23		62
Phoradendron californicum	"	WP	12	30	1.03	.20	46		50
Quercus turbinella	"	LE	8	40	.77	.19	58		41
		ST	4	53	1.01	.10			33
Rhamnus crocea	11-27-67	LE	10	36	1.41	.14	47	40	38
		ST	4	44	1.06	.10		33	33
Rhus ovata	"	LE	5	52	1.97	.23	43	42	
Simmondsia chinensis	"	LE	13	31	1.35	.12	47	36	
		ST	8	41	.66	.11		31	
Forbs									
Artemisia ludoviciana	"	WP	7	35	1.31	.30	39	37	38
Bromus rubens	12-1-69	WP	27	26	.33	.65	14		74
Erodium cicutarium	11-27-69	WP	20	31	2.51	.47	28		40
Euphorbia melanadenia	"	WP	6	29	1.30	.15	50	53	60
Franseria confertiflora	"	WP	16	32	2.61	.37	38	47	
Margaranthus solanaceus	12-1-69	WP	17	41	1.99	.47	22		39
Porophyllum gracile	11-27-67	WP	6	46	1.48	.16	46	32	
Sphaeralcea sp.	"	WP	10	45	1.63	.22	46	40	

1/ LE = Leaves, ST = Stems, FR = Fruit, FL = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

Table 5. Chemical analyses and in vitro digestibility for January forages (percent).

Plant species	Plant collection date	Plant1/ part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	Dry matter	In vitro digestibility (Dry matter disappearance) Mule deer	White-tailed deer
Browse									
Ceanothus greggii	1-5-68	LE	10	30	1.61	.14	552/	45	40
		ST	5	54	.64	.09		24	25
Cercocarpus betuloides	"	LE	12	47	1.53	.18	52	36	33
		ST	7	54	.80	.15		27	27
Eriogonum wrightii	"	WP	6	52	.61	.15	66	16	13
Quercus turbinella	1-1-70	LE	8	37	1.00	.17	58	38	
		ST	4	50	1.24	.11		27	
Rhamnus crocea	1-5-68	LE	10	31	1.52	.13	47	48	45
		ST	4	45	1.00	.10		43	41
Rhus ovata	"	LE	6	31	1.32	.13	50	49	52
		ST	3	38	1.37	.04		39	44
Simmondsia chinensis	"	LE	11	25	.93	.10	44	44	
		ST	8	41	.42	.11		35	
Forbs									
Artemisia ludoviciana	"	WP	8	44	.93	.24	50	58	42
Bromus rubens	"	WP	18	35	1.29	.64	23	55	52
Dichelostemma pulchellum	"	WP	21	22	1.05	.50	14	85	82
Erodium cicutarium	1-1-70	WP	19	24	2.55	.59	20	57	66
Euphorbia melanadenia	1-5-68	WP	6	35	1.03	.16	68	51	48
Franseria confertiflora	1-1-70	WP	21	34	2.20	.46	26	52	58
Lupinus succulentus	"	WP	18	33	.90	.59	18	57	60

1/ LE = Leaves, ST = Stems, FR = Fruit, FL = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

Table 6. Chemical analyses and in vitro digestibility for February-April forages (percent).

Plant species	Plant collection date	Plant part	Crude protein	Acid-detergent fiber	Calcium	Phosphorus	Dry matter	In vitro digestibility (Dry matter disappearance)	
								Mule deer	White-tailed deer
Browse									
Aplopappus laricifolius	3-1-67	WP	13	27	1.06	.12	38	66	
Ceanothus greggii	"	LE	12	33	1.05	.21	51 2/	41	48
		ST	5	54	.60	.09		20	
Ceanothus integerrimus	"	LE	19	26	2.18	.26	41		51
Cercocarpus betuloides	"	LE	12	32	2.07	.23	49		42
		ST	8	51	.89	.17			24
Eriogonum wrightii	"	WP	7	41	1.21	.19	55	19	22
Lonicera interrupta	"	LE	8	22	1.86	.25	42		52
Quercus turbinella	"	LE	10	40	.66	.17	58	36	34
		ST	5	54	.90	.11			18
Rhamnus crocea	"	LE	10	42	.95	.28	49		37
		ST	5	46	1.11	.09			30
Rhus ovata	"	LE	5	39	1.25	.14	48		45
Simmondsia chinensis	"	LE	11	29	1.53	.28	44	45	
		ST	8	40	.73	.32		28	
Forbs									
Anemone tuberosa	3-3-69	WP	12	26	.66	.32	20	73	79
Arabis perennans	3-1-67	WP	8	25	2.50	.35	22	67	
Artemisia ludoviciana	3-3-69	WP	17	41	1.24	.54	23	59	65
Bromus rubens	3-1-67	WP	11	35	1.96	.39	33	72	67
Dichelostemma pulchellum	"	WP	13	20	.95	.42	15	69	74
Erodium cicutarium	"	WP	22	24	.66	.16	17	66	60
Euphorbia melanadenia	"	WP	7	29	1.72	.49	67	53	
Lotus rigidus	"	WP	17	40	.43	.16	29	47	45
Lotus sp. (annual)	3-3-69	WP	17	21	2.39	.41	16	45	
Lupinus succulentus	"	WP	22	24	1.18	.48	16	50	
Marah gilensis	3-1-67	WP	36	27	.53	.77	12	75	75
Sphaeralcea sp.	"	WP	20	23	1.75	.39	31	59	
Verbena wrightii	"	WP	15	23	.68	.15	27		68

1/ LE = Leaves, ST = Stems, FR = Fruit, FL = Flower, WP = Whole plant.
2/ Dry matter is given for leaves and stems combined for those browse species later separated after drying.

SUMMARY AND CONCLUSIONS

Deer in central Arizona chaparral and desert habitats escape severe seasonal decreases in forage quality and quantity characteristic of other regions because of mild winter climate and winter:summer precipitation patterns. Except for protracted droughts, some good-quality forages are available at all seasons. Few individual species are well-balanced in all important nutrient factors, however.

Leaves of abundant browse species supply the major portion of yearlong dry matter intake, yet they tend to be only moderate to fair in nutritive value when dormant. Woody-plant fruits have long been viewed as prime deer feeds. Chemical analyses and *in vitro* digestibility trials support this observation. It is important that multiple use management programs retain or enhance shrub fruit production in habitat improvement practices involving shrub control in this area.

Herbaceous forages tend to be higher than browse in protein, phosphorus, and digestibility, lower in fiber and dry matter. Although forbs collectively comprise a lower portion of total dry matter intake in deer diets, nutritional superiority weights their contribution beyond mere volume. Consequently, nutrients below apparent minimum levels in dormant browse are supplemented by smaller but significant amounts of forbs high in these nutrients.

Current estimates of protein content and digestibility probably are minimal. Drying forage samples at 100°C tends to decrease nitrogen content and increase indigestible fractions (Van Soest 1965). In addition, hand-sampled forages are likely to be poorer in nutritive content than material from the same species selected by free-ranging deer (Dietz et al. 1958, Klein 1962, Lauckhart 1962, Swift 1948, and Wilson 1969).

Further research is needed to determine if undesirably low phosphorus contents in winter forages collectively represent deficiency levels severe enough to adversely influence reproductive performance. Other nutrients tested appear more than adequate for maintenance and reasonable production.

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Part III: Nutritional Value of Seasonal Deer Diets

by P.J. Urness and C.Y. McCulloch

INTRODUCTION

Parts I and II of this bulletin present data on seasonal diet composition and nutritive values of forages for mule deer and Coues white-tailed deer. These data provide a basis for evaluating the probable quality of the diets of adult deer at least with respect to specific nutrient factors including protein and phosphorus intake and digestibility.

Estimates of nutrient intake in the total diet can be derived by weighting the contribution of each forage species as a multiple of its nutrient content and its percent in the diet. Although actual intake cannot be measured with great precision by this means, a useful index results that can adequately define a deficiency problem should one exist.

Examination of most forage species and classes in seasonal deer diets has necessitated a review of previous ideas that forage quality is the factor limiting deer populations in Arizona chaparral and desert habitats (Swank 1958, Urness et al. 1971). Low nutrient levels in dormant browse species appear to be compensated by higher levels in other forage classes.

The data should benefit deer range managers by providing better information with which to plan vegetation modification programs for deer habitat improvement, assess impacts of other land management activities, and develop more comprehensive deer range condition surveys.

METHODS

Information on relative values of seasonal deer forages is essential to sound game range management. Until recently such data were sparse for Arizona chaparral and desert habitats. McCulloch (Part I) has determined the seasonal diet composition of Three Bar deer by plant species, plant part, and frequency percent (volume). A knowledge of diet composition, although important, falls short of relative value since nutritive quality is highly variable among species and seasons.

Analyses for specific nutrients and digestibility for most plant species and structures appearing in seasonal deer diets at Three Bar were summarized (Urness, Part II). Alone, these data also form only a partial picture of relative value. However, when diet composition and nutritive content are combined, a comparative measure of relative value results.

For example, an index for relative protein values for mule deer forages in May-June is determined by multiplying the protein content of each species by the percent that species comprises of the diet. This weighted value can be compared to other species in relation to their contribution of total weighted protein (Table 1). On the basis of protein alone, calliandra *(Calliandra eriophylla)* is obviously the most important species during early summer, followed by ratany *(Krameria parvifolia)* and jojoba *(Simmondsia chinensis)*. Percentage protein intake can be estimated by dividing the total weighted protein value by the percent of the diet tested. Thus, mule deer in May-June have an approximate dietary protein intake of 12 percent (1096 : 94 = 11.7).

Similar indexes for acid-detergent fiber, calcium, phosphorus, and digestibility have been developed, Nutrient values for browse leaves were used in the calculations of dietary intake because very little stem or twig material has been found in deer rumens (McCulloch 1967:71). Ideally, total diets should be tested, but invariably data are lacking for some forage species, usually those of minor percentage in the diet. Minor species are frequently high in nutritive quality, and their omission tends to make these nutrient estimates somewhat conservative.

Table 1. Relative protein values of Three Bar mule deer forages during the May-June feeding period.

Species	Plant part[1/]	% Diet comp.	% Protein content	Weighted intake
Calliandra eriophylla	LE	24	15	360
Krameria parvifolia	LE	9	14	126
Simmondsia chinensis	LE	12	10	120
Psoralea sp.	WP	6	16	96
Simmondsia chinensis	FR	6	11	66
Ceanothus greggii	LE	4	15	60
Yucca baccata	FL	4	11	44
Rhus ovata	LE	6	6	36
Lupinus succulentus	WP	2	14	28
Menodora scoparia	WP	3	9	27
Calochortus kennedyi	WP	3	9	27
Ceanothus greggii	FR	2	12	24
Nolina microcarpa	LE	6	4	24
Euphorbia melanadenia	WP	4	6	24
Marah gilensis	WP	1	16	16
Rhamnus crocea	LE	1	10	10
Cuscuta sp.	WP	1	8	8
		94		1096

1/ LE = Leaves
WP = Whole plants
FR = Fruit
FL = Flower stalks

RESULTS

Comparative values of seasonal forages and estimated seasonal nutrient intakes appear in Tables 2-7. While the tabulated values are not absolutes, we believe they represent a reasonably accurate ranking of relative values among the forage species in seasonal diets. The data frequently show that neither diet composition nor nutritive content alone provide an adequate index to relative values, and that the range nutrition subject is complex indeed. For example, species high in protein often contribute less to total protein intake than species containing moderate protein but eaten in greater amounts. Furthermore, the value of some plants relatively high in phosphorus may be largely negated by excessive calcium levels antagonistic to phosphorus metabolism.

May-June. Table 2 is a compilation of all late spring data for both mule deer and Coues white-tailed deer. Although the table appears complicated, it is but a repetition of the procedure illustrated in Table 1 for each of the five nutrient factors studied. Nutrient intake percentages are remarkably similar for both deer species, despite considerable differences in diet composition and habitat selection.

Protein intake is 12 percent or higher for both species of deer. Calliandra, ratany, and jojoba were most important sources for mule deer but, combined, supplied slightly more than half the protein. Bigleaf ceanothus *(Ceanothus integerrimus)*, although eaten in lesser amounts, was a more important protein source than either calliandra or ratany for white-tailed deer.

Acid-detergent fiber intake was only 35 percent despite the dominant position of browse forages in total diets. Fiber percentages were apparently kept down by selective use of spring leaves that had not matured completely. Most forb species consumed in late spring were as fibrous as leaves of the better browse forages, reflecting incipient maturity.

Calcium intake at .88 percent was relatively low but well above minimum requirements (probably .10 — .20 percent, Verme and Ullrey 1972). Calliandra and scurf-pea *(Psoralea sp.)* contributed heavily to early summer calcium intake. Forbs as a class tended to be higher in calcium than browse at this time with some notable exceptions, dodder *(Cuscuta sp.)*, a forb, and holly-leaf buckthorn *(Rhamnus crocea)*, a shrub.

The May-June estimates of phosphorus intake slightly exceed the probably deer minimum requirement of from .16 — .25 percent (Dietz 1965:277). These estimates may be minimal because they do not take into account selective feeding behavior that deer exhibit. Also, calcium is relatively low during this period in most available forages, so phosphorus:calcium ratios are moderate at about 1:3.

Digestibility estimates in late spring are higher for mule deer (43 percent) than white-tailed deer (36 percent). A greater variety of more highly digestible forbs was available to mule deer at lower elevations. Furthermore mule deer inocula digested the same browse species better than that of white-tailed deer during this period. The fact that only 82 percent of the white-tailed deer diet was analyzed may also account for part of the difference. For example, highly digestible *Yucca baccata* flower stalks, making up 5 percent of the white-tailed deer diet, were not analyzed.

July-September. Data for the summer period appear in Table 3. Browse fruits were very important to both deer species, comprising nearly two-thirds or more of total diets. Little herbaceous forage is available during midsummer.

Protein intake is the highest (14 percent) of the year for mule deer because a high percentage of leguminous fruits were consumed, namely, those of mesquite *(Prosopis juliflora)* and catclaw acacia *(Acacia greggii)*. White-tailed deer protein intake is moderate (9 percent) as a result of large amounts of oak mast in the diet which was notably low in protein.

Fiber levels were moderate but higher than expected for diets dominated by fruiting structures. A partial explanation lies in the tough seed coats encasing acorns and other woody plant seeds. The relatively high fiber of cactus fruits may well be a result of lignification caused by scorching when oven-dried at 100°C. Fresh or freeze-dried fruit samples could test much lower in fiber.

Calcium content in summer diets is lower than other periods in the annual cycle. White-tailed deer calcium intake (.66 percent) was especially low but well above estimated minimum requirements. Shrub fruits tend to accumulate calcium at a lower level than leaves except shrub live oak.

Phosphorus intake was somewhat lower than in late spring but calcium was also lower, resulting in little net change in the P:Ca ratios (1:3-3.6). Mesquite and catclaw acacia beans are good sources of phosphorus for mule deer, while skunkbush fruits and artemisia herbage are outstanding contributors to phosphorus intake for white-tailed deer.

Digestibility of summer diets was moderate to low, reflecting the fibrous nature of shrub seed coats and capsules. Cactus fruit and mesquite beans help to offset low digestibilities in browse leaves. White-tailed deer diets are lower in digestibility because of the dominant position of oak acorns.

October. Fall diets diverge more dramatically than any other period in the year (Table 4). Mule deer concentrate on calliandra and secondarily on other browse, while white-tailed deer feed more heavily on upper elevation forbs resulting from effective summer rains. It is remarkable, then, that estimated nutrient intake percentages, except digestibility, were in so close agreement.

Protein intakes at 12 percent were quite good despite the generally dry conditions in desert habitats. The few forbs taken by mule deer were near maturity and poor protein sources. The reverse is true for white-tailed deer at higher elevations in the chaparral type, where many fall forbs are high in protein. Some growth of evergreen browse leaves stimulated by summer rainfall was near peak protein content.

Dietary fiber is elevated to some extent above the spring-summer levels. The few forbs eaten by mule deer are little lower in fiber than the better browse leaves. Jojoba leaves are particularly low in fiber for a browse plant in fall. White-tailed deer have a larger number of forages available yet the forb species of greatest importance, redstar morningglory *(Ipomoea coccinea)*, was relatively high in fiber.

Calcium intake rose sharply in October compared to late spring and summer percentages primarily because of shifts to species high in calcium rather than general seasonal calcium increases. Because there was no concomitant increase in phosphorus, the phosphorus : calcium ratio widened undesirably.

Fiber intakes were similar but there was a considerable difference between deer species in estimated mean digestibility. Browse leaves, particularly calliandra, were low in digestibility, which explains the low mule deer percentage. Dominance of highly digestible forbs in white-tailed deer diets raised the average percentage dramatically above late spring-summer levels.

November-December. Late fall-early winter diets of mule and white-tailed deer have only six species in common but they comprise over half of the diets (Table 5). There are, however, sufficient differences in composition to cause some divergence in nutrient intake levels. As in October, browse leaves appeared in greater proportion in mule deer diets, while forbs retained a higher position in white-tailed deer diets.

Protein intakes were similar, illustrating retention of good protein levels in the important browse leaves and a generally low protein content in prominent forbs. Although intake levels appeared adequate they were the lowest of the year for mule deer.

Fiber intake of mule deer increased to the highest percentage for the year. Moderate fiber in jojoba was offset by high fiber in calliandra. Fiber intake for white-tailed deer is significantly lower because of very low fiber content in bigleaf ceanothus and moderate levels in spurge.

Calcium rose to the yearly high for both deer species. Most forages that occurred in October and November-December diets showed a significant increase in calcium during the latter period. At the same time phosphorus declined sharply in many mule deer forages, with the result that the P:Ca ratio (1:10) became very wide, possibly representing dietary deficiency at this season. The ratio is also undesirably wide in white-tailed deer diets (1:8). The possibility of or need for improving this ratio by soil amendments of phosphate fertilizers has not been adequately explored.

Digestibility varied inversely with fiber levels in entire diets, but was not consistent among individual species. Jojoba had 31 percent fiber and was digested by mule deer at only 36 percent, while spurge had

29 percent fiber and was digested at 53 percent. The significantly higher average digestibility for white-tailed deer was largely attributable to the remarkably high digestibility of bigleaf ceanothus and spurge.

January. Species composition in midwinter diets was nearly the same for both deer species (Table 6). Although percentage composition differs somewhat, the difference tended to compensate with the result that intakes of all nutrient factors tested were closely similar. Use of high-quality winter-active forbs effects a general improvement in nutrient intake above November-December levels.

Protein content of new herbaceous growth was high, but greater use of lower value browse keeps protein intake at 11 percent. This level, while adequate, was below the yearlong average for mule deer. That deer did not select plants specifically for protein was illustrated by eriogonum, which is abundant but low in protein (6 percent) while mountain-mahogany, also abundant but a better protein source (12 percent) was eaten in much smaller amounts.

High fiber intake although not likely excessive, was heavily weighted by the large amounts of fibrous eriogonum in both deer diets. In view of the abundance of seemingly superior forages, it is paradoxical that eriogonum (low in protein, phosphorus, and digestibility; high in fiber) was so prominent in midwinter deer diets.

Eriogonum was, however, lower in calcium than all other forages during this period. As a result the calcium intake estimates for January dropped dramatically below November-December levels. Still, the phosphorus:calcium ratios (1:5) are near the presumed widest level desirable for any sustained period.

Many winter-active forbs had moderately high phosphorus content but intakes are minimal because the bulk of the diets was composed of mature browse, low in phosphorus. Grass-nuts was an especially good source of phosphorus. Red brome *(Bromus rubens)* usually initiates abundant growth in January and is high in phosphorus, but deer inexplicably consume only small amounts. Absence of overt "pica" behavior, such as ingestion of bone, further indicates that phosphorus intakes, although low, are not at deficiency levels.

Digestibility of January forages is about the yearly average. Highly digestible midwinter forbs compensate for some poorly digested browse (grass-nuts is very high and eriogonum is very low in *in vitro* digestibility). There was a net improvement in dietary digestibility for mule deer over October and November-December levels because of the onset of new forb growth at lower elevations. Data for white-tailed deer, however, show a decline in digestibility coincident with the decline of forbs in the diet during the same period.

February-April. Late winter-early spring diets, especially for mule deer, shift strongly to high-quality forbs. Much of the browse eaten during this period is new growth and of greater value than the same species in midwinter. Consequently, nutrient intakes improve appreciably to some of the best levels of the year.

Protein intakes of about 13 percent approach levels that permit maximum gains and production in other deer herds (Murphy and Coates 1966, Verme and Ullrey 1972). Spring forbs contribute more than browse to protein intake for mule deer, but the two forage classes supply protein in about the same proportion as they appear in the white-tailed deer diet.

Fiber intake was the lowest of the year for both deer species, reflecting succulence of new plant tissue. Low fiber was related to high digestibility (51 and 52 percent) during this period, but the relationship was not consistent at other seasons. Most late winter-early spring forbs were highly digestible, some well above 70 percent, with the average slightly more than 60 percent.

High calcium content of forbs raised intake levels somewhat above those in midwinter. Phosphorus content was also higher, resulting in narrower phosphorus:calcium ratios. The ratios (1:4.4 for mule deer and 1:4.2 for white-tailed deer) are still above desired levels but likely within upper limits readily tolerated by adult deer.

Table 2. Estimated nutrient intake for deer from May through June at Three Bar.

Plant species	Plant part and class	Percent of diet composition		Relative intake (weighted value)[1/]								In vitro digestibility	
				Protein		Acid-detergent fiber		Calcium		Phosphorus			
		MD	WT	MD[2/]	WT	MD	WT	MD	WT	MD	WT	MD	WT
<u>Calliandra eriophylla</u>	Browse - LE	24	12	360	180	888	444	21.84	10.92	4.80	2.40	672	240
<u>Ceanothus greggii</u>	LE	4	5	60	75	140	175	3.28	4.10	1.08	1.35	192	155
	FR	2		24		78		1.26		.42		86	
<u>Ceanothus integerrimus</u>	LE		9		207		306		11.97		3.06		297
<u>Garrya flavescens</u>	LE		2		16		80		1.90		.60		72
<u>Krameria parvifolia</u>	LE	9	12	126	168	387	516	6.48	8.64	4.14	5.52	360	372
<u>Nolina microcarpa</u>	LE	6		24		330		3.72		.96		156	
<u>Quercus turbinella</u>	LE		6		78		228		2.58		1.92		198
<u>Rhamnus crocea</u>	LE	1	6	10	60	39	234	1.84	11.04	.12	.72	58	162
<u>Rhus ovata</u>	LE	6	16	36	96	222	592	6.24	16.64	1.32	3.52	228	528
<u>Simmondsia chinensis</u>	LE	12		120		312		6.84		2.40		564	
	FR	6		66		240		4.74		1.20		276	
<u>Yucca baccata</u>	FL	4		44		96		1.60		1.86		300	
<u>Calochortus kennedyi</u>	Forb - WP	3		27		111		2.49		.96		168	
<u>Cuscuta</u> sp.	WP	1	7	8	56	19	133	.14	.98	.22	1.54	71	497
<u>Euphorbia melanadenia</u>	WP	4		24		112		3.80		1.12		248	
<u>Lupinus succulentus</u>	WP	2		28		76		2.34		.70		126	
<u>Marah gilensis</u>	WP	1		16		29		2.68		.43		52	
<u>Menodora scoparia</u>	WP	3		27		126		2.85		.69		138	
<u>Psoralea</u> sp.	WP	6		96		168		10.50		1.44		384	
<u>Solanum xanti</u>	WP		3		36		108		2.85		1.02		153
	FR		4		20		84		.80		1.28		244
Totals		94	82	1096	992	3373	2900	82.64	72.42	23.86	22.93	4079	2918
Estimated nutrient intake percentage[3/]				12	12	36	35	.88	.88	.25	.28	43	36

1/ Derived by multiplying nutrient content percentage by the diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing the total weighted value of relative intake by the total diet composition percentage.

Table 3. Estimated nutrient intake for deer from July through September at Three Bar.

Plant species	Plant part and class	Percent of diet composition		Relative intake (weighted value)[1/] Protein		Acid-detergent fiber		Calcium		Phosphorus		In vitro digestibility	
		MD	WT	MD[2/]	WT	MD	WT	MD	WT	MD	WT	MD	WT
Acacia greggii	Browse - FR	14	2	210	30	490	70	9.80	1.40	3.92	.56	448	58
Calliandra eriophylla	LE	13	3	182	42	442	102	15.47	3.57	2.86	.66	416	
Carnegiea gigantea	FR	2		26		62		.62		.68		128	
Ceanothus integerrimus	LE		3		45		96		4.95		.51		162
Garrya flavescens	FR		6		42		336		3.66		1.74		186
Opuntia engelmannii	FR	2		18		58		5.06		.52		98	
Prosopis juliflora	FR	29	9	493	153	1015	315	22.33	6.93	7.25	2.25	1566	459
Quercus emoryi	FR		9		54		522		3.15		1.17		270
Quercus turbinella	LE	1	1	11	11	51	51	.57	.57	.21	.21	35	41
	FR	14	33	84	198	406	957	9.24	21.78	2.24	5.28	490	1144
Rhamnus crocea	LE		4		36		204		5.28		.60		132
Rhus trilobata	FR		11		99		385		2.42		3.85		440
Simmondsia chinensis	LE	5		100		120		4.25		.80		215	
	FR	1		12		49		.22		.23		44	
Artemisia ludoviciana	Forb - WP	2	13	18	117	88	572	1.28	8.32	.64	4.16		481
Totals		83	94	1154	827	2781	3610	68.84	62.03	19.35	20.99	3440	3373
Estimated nutrient intake percentage[3/]				14	9	34	38	.83	.66	.23	.22	42	37

1/ Derived by multiplying nutrient content percentage by diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing total weighted value of relative intake by total diet composition percentage.

Table 4. Estimated nutrient intake for deer in October at Three Bar.

Plant species	Plant part and class	Percent of diet composition MD	Percent of diet composition WT	Relative intake (weighted value)[1]: Protein MD[2]	Protein WT	Acid-detergent fiber MD	Acid-detergent fiber WT	Calcium MD	Calcium WT	Phosphorus MD	Phosphorus WT	In vitro digestibility MD	In vitro digestibility WT
Calliandra eriophylla	Browse - LE	71	7	923	91	2698	266	92.30	9.10	20.59	2.03	2343	224
Ceanothus greggii	LE	1	2	12	24	49	98	.67	1.34	.25	.50	37	78
Ceanothus integerrimus	LE		5		80		165		12.35		.80		290
Cercocarpus betuloides	LE	1	1	13	13	53	53	1.66	1.66	.14	.14	33	32
Eriogonum wrightii	WP		2		16		102		1.88		.30		48
Gutierrezia sarothrae	WP	1	1	10	10	40	40	1.42	1.42	.20	.20	45	53
Rhamnus crocea	LE	5	8	50	80	225	360	2.55	4.08	.60	.96	180	320
Rhus trilobata	LE		1		9		46		1.19		.33		31
Simmondsia chinensis	LE	9		117		306		8.37		1.53		360	
Artemisia ludoviciana	Forb - WP	4	5	36	45	176	220	1.76	2.20	1.08	1.35	132	265
Euphorbia melanadenia	WP	3	21	21	147	84	588	3.30	23.10	.69	4.83	195	1281
Franseria confertiflora	WP		1		17		42		2.10		.34		53
Ipomoea coccinea	WP		31		465		1395		42.78		5.89		2046
Margaranthus solanaceus	WP		1		13		32		1.82		.25		63
Mentzelia pumila	WP		1		9		36		1.61		.24		60
Porophyllum gracile	WP	3		21		132		6.90		.60		132	
Solanum xanti	WP		1		19		26		1.65		.27		61
Totals		98	88	1203	1038	3763	3469	118.93	108.28	25.68	18.43	3457	4905
Estimated nutrient intake percentage[3]				12	12	38	39	1.21	1.23	.26	.21	35	56

1/ Derived by multiplying nutrient content percentage by diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing total weighted value of relative intake by total diet composition percentage.

Table 5. Estimated nutrient intake for deer from November through December at Three Bar.

Plant species	Plant part and class	Percent of diet composition		Relative intake (weighted value)[1/] Protein		Acid-detergent fiber		Calcium		Phosphorus		In vitro digestibility	
		MD	WT	MD[2/]	WT	MD	WT	MD	WT	MD	WT	MD	WT
Acacia greggii	Browse - LE		1		10		50		2.66		.11		28
Aplopappus laricifolius	WP	3		24		153		3.99		.60		165	
Calliandra eriophylla	LE	24	19	264	209	1080	855	48.96	38.76	3.33	2.66	648	589
Ceanothus greggii	LE		1		9		29		1.69		.15		45
Ceanothus integerrimus	LE		14		196		308		36.82		1.96		854
Cercocarpus betuloides	LE	4	1	40	10	184	46	7.04	1.76	.60	.15	124	29
Eriogonum wrightii	WP	9	2	45	10	450	100	9.00	2.00	1.35	.30	144	54
Garrya flavescens	LE		2		10		82		2.10		.98		116
Lonicera interrupta	LE		3		24		84		6.00		.90		186
Phoradendron californicum	WP		1		12		30		1.03		.20		50
Quercus turbinella	LE		1		8		40		.77		.19		41
Rhamnus crocea	LE	4	2	40	20	144	72	5.64	2.82	.56	.28	160	94
Rhus ovata	LE	4		20		208		7.88		.92		168	
Simmondsia chinensis	LE	27		351		837		36.45		3.24		972	
Artemisia ludoviciana	Forb - WP	6	15	42	105	210	525	7.86	19.65	1.80	4.50	222	570
Bromus rubens	WP		3		81		78		.99		1.95		222
Erodium cicutarium	WP		3		60		93		7.53		1.41		120
Euphorbia melanadenia	WP	7	15	42	90	203	435	9.10	19.50	1.05	2.25	371	900
Franseria confertiflora	WP	1		16		32		2.61		.37		47	
Margaranthus solanaceus	WP		2		34		82		3.98		.94		78
Porophyllum gracile	WP	1		6		46		1.48		.16		32	
Sphaeralcea sp.	WP	2		20		90		3.26		.44		80	
Totals		92	85	910	888	3637	2909	143.27	148.06	14.42	18.93	3133	3976
Estimated nutrient intake percentage[3/]				10	10	40	34	1.56	1.74	.16	.22	34	47

1/ Derived by multiplying nutrient content percentage by diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing total weighted value of relative intake by total diet composition percentage.

Table 6. Estimated nutrient intake for deer in January at Three Bar.

Plant species	Plant part and class	Percent of diet composition		Relative intake (weighted value)[1]								In vitro digestibility	
				Protein		Acid-detergent fiber		Calcium		Phosphorus			
		MD	WT	MD[2]	WT	MD	WT	MD	WT	MD	WT	MD	WT
Ceanothus greggii	Browse - LE	4	19	40	190	120	579	6.44	30.59	.56	2.66	180	760
Cercocarpus betuloides	LE	8	5	96	60	376	235	12.24	7.65	1.44	.90	288	165
Eriogonum wrightii	WP	33	18	198	108	1716	936	20.13	10.98	4.95	2.70	528	234
Quercus turbinella	LE	1		8		37		1.00		.17		38	
Rhamnus crocea	LE	3	15	30	150	93	465	4.56	22.80	.39	1.95	144	675
Rhus ovata	LE	3	4	18	24	93	124	3.96	5.28	.39	.52	147	208
Simmondsia chinensis	LE	20		220		500		18.60		2.00		880	
Artemisia ludoviciana	Forb - WP	2	4	16	32	88	176	1.86	3.72	.48	.96	116	168
Bromus rubens	WP	1	4	18	72	35	140	1.29	5.16	.64	2.56	55	208
Dichelostemma pulchellum	WP	11	7	231	147	242	154	11.55	7.35	5.50	3.50	935	574
Erodium cicutarium	WP	2	2	38	38	48	48	5.10	5.10	1.18	1.18	114	132
Euphorbia melanadenia	WP	1	6	6	36	35	210	1.03	6.18	.16	.96	51	288
Franseria confertiflora	WP	1	1	21	21	34	34	2.20	2.20	.46	.46	52	58
Lupinus succulentus	WP	2	4	36	72	66	132	1.80	3.60	1.18	2.36	114	240
Totals		92	89	976	950	3483	3233	91.76	110.61	19.50	20.71	3642	3710
Estimated nutrient intake percentage[3]				11	11	38	36	1.00	1.24	.21	.23	40	42

1/ Derived by multiplying nutrient content percentage by the diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing the weighted value of relative intake by the total diet composition percentage.

Table 7. Estimated nutrient intake for deer from February through April at Three Bar.

Plant species	Plant part and class	Percent of diet composition MD	Percent of diet composition WT	Relative intake (weighted value)[1] Protein MD[2]	Protein WT	Acid-detergent fiber MD	Acid-detergent fiber WT	Calcium MD	Calcium WT	Phosphorus MD	Phosphorus WT	In vitro digestibility MD	In vitro digestibility WT
Aplopappus laricifolius	Browse - WP	2		26		54		2.12		.24		132	
Ceanothus greggii	LE	2	1	24	12	66	33	2.10	1.05	.42	.21	82	48
Ceanothus integerrimus	LE		2		38		52		4.36		.52		102
Cercocarpus betuloides	LE		15		180		480		31.05		3.45		630
Eriogonum wrightii	WP	13	6	91	42	533	246	15.73	7.26	2.47	1.14	247	132
Lonicera interrupta	LE		4		32		88		7.44		1.00		208
Quercus turbinella	LE	1	3	10	30	40	120	.66	1.98	.17	.51	36	102
Rhamnus crocea	LE		9		90		378		8.55		2.52		333
Rhus ovata	LE		4		20		156		5.00		.56		180
Simmondsia chinensis	LE	23		253		667		35.19		6.44		1035	
Anemone tuberosa	Forb - WP	4	1	48	12	104	26	2.64	.66	1.28	.32	292	79
Arabis perennans	WP	5		40		125		12.50		1.75		335	
Artemisia ludoviciana	WP	2	9	34	153	82	369	2.48	11.16	1.08	4.86	118	585
Bromus rubens	WP	1	4	11	44	35	140	1.96	7.84	.39	1.56	72	268
Dichelostemma pulchellum	WP	13	14	169	182	260	280	12.35	13.30	5.46	5.88	897	1036
Erodium cicutarium	WP	10	4	220	88	240	96	6.60	2.64	1.60	.64	660	240
Euphorbia melanadenia	WP	2		14		58		3.44		.98		106	
Lotus rigidus	WP	8	1	136	17	320	40	3.44	.43	1.28	.16	376	45
Lotus sp. (annual)	WP	6		102		126		14.34		2.46		270	
Lupinus succulentus	WP	2		44		48		2.36		.96		100	
Marah gilensis	WP		1		36		27		.53		.77		75
Sphaeralcea sp.	WP	2		40		46		3.50		.78		118	
Verbena wrightii	WP		2		30		46		1.36		.30		136
Totals		96	80	1262	1006	2804	2577	121.41	104.61	27.76	24.40	4876	4199
Estimated nutrient intake percentage[3]				13	13	29	32	1.27	1.31	.29	.31	51	52

1/ Derived by multiplying nutrient content percentage by the diet composition percentage.
2/ MD = Desert mule deer. WT = Coues white-tailed deer.
3/ Derived by dividing the weighted value of relative intake by the total diet composition percentage.

DISCUSSION

Seasonal estimates of average nutrient factor intakes are graphed in Figures 1-4. Figure 1 shows the inverse relationship between mean acid-detergent fiber and digestibility for mule deer. Fiber levels appeared somewhat high at 40 percent in early winter and digestibility was low at 34 percent. Neither level represents an apparent problem to deer metabolism (Nagy et al. 1969), but reflects the dominant position of mature browse leaves in seasonal diets. However, these data were based on hand-clipped forage samples. The likely effect of analyzing samples collected by deer would be a lowering of fiber percentages and increased digestibility.

Protein intake varied little yearlong, indicating availability of forages high in protein at all seasons and ability of mule deer to shift seasonal diet composition to exploit them. A yearly average of 12 percent protein is considered adequate for growth and reasonable production (Murphy and Coates 1966). Furthermore, the methods of collecting and preparing forage samples undoubtedly resulted in minimum estimates of protein content.

Data for white-tailed deer did not exhibit the consistent inverse relationship between acid-detergent fiber and digestibility found in mule deer, but the yearly percentages were not materially different (Fig. 2). Fiber levels were especially close among deer species, but digestibility of white-tailed deer diets is elevated significantly during fall and early winter.

Protein intake of white-tailed deer was slightly lower than that of mule deer but equally uniform throughout the year. The only significant differences occured in midsummer when mule deer consumed large amounts of leguminous shrub fruits high in protein, while low-protein acorns dominated white-tailed deer diets.

The foregoing does not offer any clues to forage quality limitations potentially responsible for generally poor fawn survival in central Arizona during recent years (Smith et al. 1969). However, seasonably low phosphorus and high calcium might have an adverse influence. Dietz (1965:277) suggests that phosphorus intakes at or below 0.16 percent could adversely affect reproduction. Figures 3 and 4 indicate that phosphorus levels are generally above .20 percent for central Arizona deer. The problem of low phosphorus is compounded, however, when calcium intake is high due to the ability of calcium to inhibit the metabolism of phosphorus. Phosphorus : calcium ratios should not exceed 1:5 (Dietz et al. 1962:53), but ratios are wider for central Arizona mule deer in early winter (November-December) and white-tailed deer from October through January, seasons when deer needs are at maintenance rather than productive levels.

There is no available evidence that phosphorus deficiency actually limits deer reproductive success on the study area. Generally high conception rates and fetal counts support a view that adult deer are not adversely affected by existing phosphorus nutrition levels. Sufficient doubt remains, however, concerning effects of inhibited phosphorus metabolism on the vigor and milk production of does with fawns (Murphy and Coates 1966) to make research into these factors both desirable and necessary if excessive fawn mortality is to be explained or reduced.

Dietz (1965) suggests other potential pathologic conditions that could result from either low diet phosphorus levels or wide phosphorus:calcium ratios. These include retarded growth, weak young, decreased lactation and conception failure.

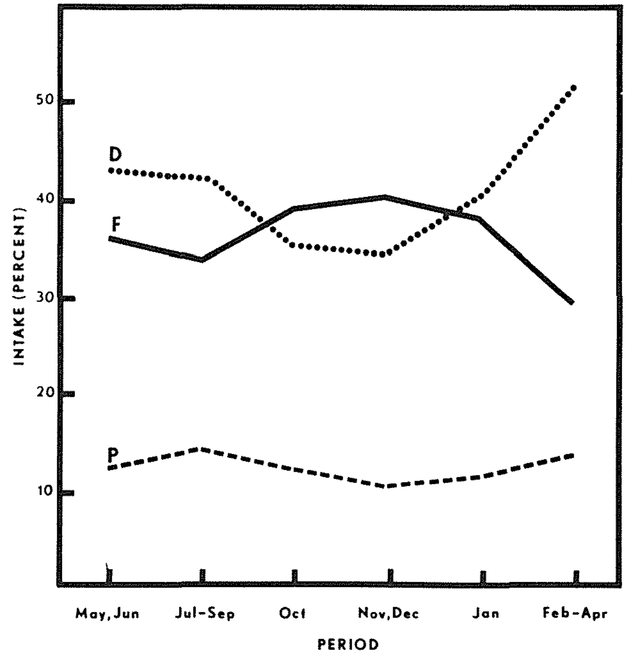

Figure 1. Annual cycle of mean digestibility (D), acid-detergent fiber (F), and protein (P) intake for central Arizona mule deer.

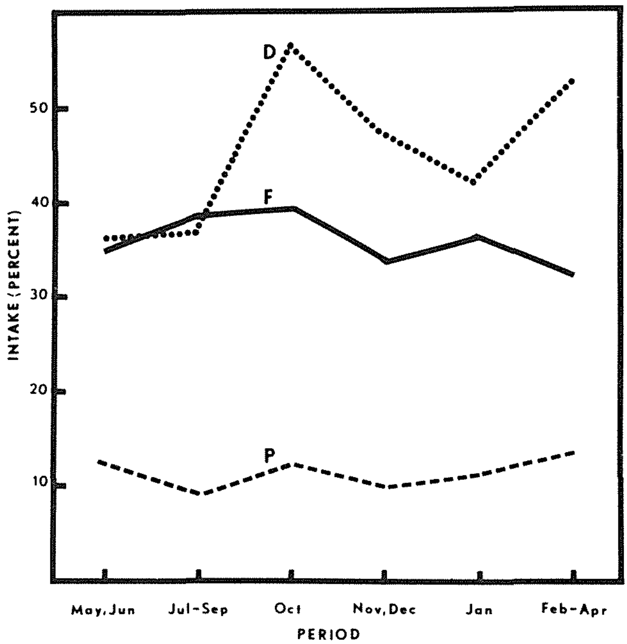

Figure 2. Annual cycle of mean digestibility (D), acid-detergent fiber (F), and protein (P) intake for central Arizona white-tailed deer.

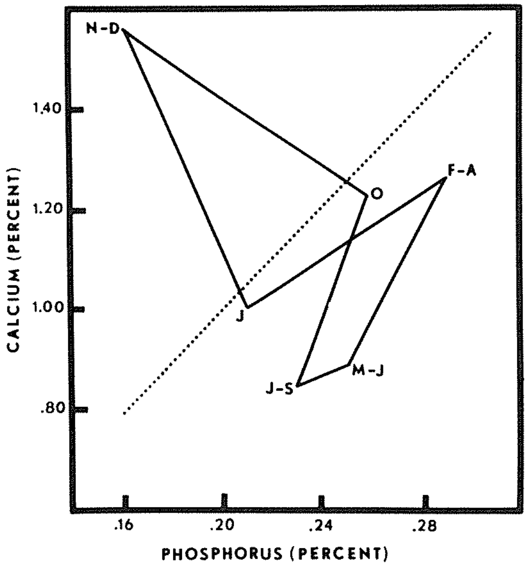

Figure 3. Annual cycle in phosphorus and calcium intake for central Arizona mule deer, the dotted line indicates the 1:5 phosphorus-calcium ratio which, if exceeded, is undesirable for deer on a sustained basis (Dietz et al. 1962).

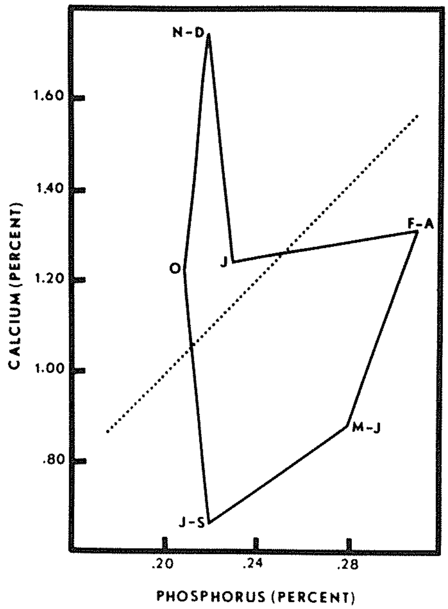

Figure 4. Annual cycle in phosphorus and calcium intake for central Arizona white-tailed deer, the dotted line indicates the 1:5 phosphorus-calcium ratio which, if exceeded, is undesirable for deer on a sustained basis (Dietz et al. 1962).

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